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July 1988



Proceedings: Workshop on Environmental Considerations in the Life-Cycle of Paints and Coatings

Edited by
Keturah A. Reinbold
Erik Hangeland

This workshop was jointly organized by the U.S. Environmental Protection Agency and the Department of the Army. It was hosted by the U.S. Army Construction Engineering Research Laboratory during September 9-10, 1986 in Champaign, Illinois.

The purpose of the workshop was to exchange information on research and development (R&D) needs and ongoing R&D for solving environmental problems related to paints and coatings and their operations. Included were environmental aspects of (1) paint formulation and manufacture, (2) paint strippers and solvents and their use and disposal, (3) disposal of sludges from paint removal, and (4) health hazards associated with paints, strippers, solvents, and sludges.



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FOREWORD

This workshop was jointly organized by the U.S. Environmental Protection Agency and the Department of Army. Members of the planning committee were as follows: U.S. Environmental Protection Agency, Cincinnati, OH--Mr. Roger Wilmoth; U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), Aberdeen Proving Grounds, MD--Mr. Robert Bartell, Chief, Research and Development, and Mr. Erik Hangeland; U.S. Army Construction Engineering Research Laboratory (USA-CERL), Champaign, IL--Dr. Edward Novak, Dr. Keturah Reinbold, Mr. Albert Beitelman, and Mr. Walter Mikucki. Dr. Clemens Meyer, U.S. Army Corps of Engineers, Research and Development Office, administratively sanctioned the workshop.

Dr. Keturah Reinbold, USA-CERL, and Mr. Erik Hangeland, USATHAMA, were co-organizers of the workshop. Mr. David Renard, USATHAMA, drafted the letters of invitation. Ms. Sharon Bloomquist, USA-CERL, provided secretarial support, and she and Ms. Joan Percival gave logistical assistance. Ms. Bloomquist and Ms. Neva Frantz assisted in the difficult and time-consuming task of interpreting and transcribing the lengthy discussions from tape recordings. Ms. Linda Wheatley provided editorial assistance.

COL N. C. Hintz is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.



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* No written paper submitted

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INTRODUCTION

The purpose of this workshop was to exchange information on research and development (R&D) needs and ongoing R&D for solving environmental problems related to paints and coatings and their operations. Included were environmental aspects of (1) paint formulation and manufacture, (2) paint strippers, solvents, and their use and disposal, (3) disposal of sludges from paint removal, and (4) health hazards associated with paints, strippers, solvents, and sludges.

Speakers from the U. S. Environmental Protection Agency, the U. S. Army, Air Force, and Navy, the Defense Reutilization and Marketing Service, and from industry addressed various aspects of the problem. Both the speakers and participants were asked to provide definitions of problems, recommendations for research and development, and suggestions as to how to carry out the recommended research and development. Topic areas covered were (1) Paint Manufacturing and Use, (2) Regulations Affecting Paints and Painting, (3) Paint Formulation, Disposal, and Waste Reduction, and (4) Research and Development. Following the presentations, there was a discussion of research needs. The titles and schedule of the presentations are listed in the workshop Program Schedule.

**PROGRAM SCHEDULE:
DA/EPA WORKSHOP ON ENVIRONMENTAL CONSIDERATIONS IN THE
LIFE-CYCLE OF PAINTS AND COATINGS**

September 9, 1986

8:30 Welcome - Dr. Louis Shaffer, Technical Director, USA-CERL

8:45 Introduction - Dr. Keturah Reinbold, USA-CERL

I. Paint Manufacturing and Use - Moderator: Walter Mikucki, USA-CERL

9:00 Keynote Address - Current Trends and Concerns Relating to Environmental Aspects of Paints and Paint Manufacturing. Steven Kish and Emmett Dunham, Enterprise Chemical Coatings.

9:30 Depot User Needs for Environmental Considerations in the Use of Paints. Pat Christman, Sacramento Army Depot.

9:55 Break

10:15 Environmental Considerations in the Use of Paints and Coatings at U.S. Army Installations. Robert Lubbert, U.S. Army Facilities Engineering Support Agency.

10:40 Environmental Problems Associated with Painting Bridges. George Norton, U.S. Army Corps of Engineers, New England Division.

11:05 Discussion

11:30 - 1:00 Lunch

II. Regulations - Moderator: Dr. Clemens Meyer, Headquarters, U.S. Army Corps of Engineers, Directorate of Research and Development

1:00 Occupational Health Aspects of Painting and Removal. William McKinnery, Occusafe, Inc.

1:25 Air Regulations Affecting Painting. Peter Spyropoulos, Region V, U.S. Environmental Protection Agency.

1:50 RCRA Waste Paint Regulations and Their Enforcement. James A. Rittenhouse, Region V, U.S. Environmental Protection Agency.

2:15 Discussion

2:40 Break

III. Paint Formulation, Disposal, and Waste Reduction - Moderator: Erik Hangeland, U.S. Toxic and Hazardous Materials Agency

3:00 Development of Vinyl Paint Systems for the U.S. Army Corps of Engineers. Alfred Beitelman, USA-CERL

- 3:25 Disposal of Hazardous and Toxic Wastes from Military/Industrial Painting Operations. George Jonas, Jr. Defense Reutilization and Marketing Service.
- 3:50 AMC Hazardous Waste Reduction Approach and Progress. William N. Hasselkus, Environmental Quality Division, U.S. Army Materiel Command
- 4:15 Discussion
- 6:00 - 7:00 Social Hour

September 10, 1986

IV. Research and Development - Moderator: Dr. Keturah Reinbold, USA-CERL

- 8:30 Technical, Environmental, and Economic Evaluations of Plastic Media Blasting for Paint Stripping. Charles Darwin and Roger Wilmoth, Office of Research and Development, U.S. Environmental Protection Agency.
- 9:15 Treatment of the Plastic Bead Blasting Residue Resulting from Paint Stripping of F-4 Aircraft. Capt. Raymond Peters, Air Force Engineering and Services Center.
- 9:40 The Investigation of Alternate Paint Strippers to Reduce Total Toxic Organics (TTO's) in Metal Finishing Wastewater. David Renard, U.S. Toxic and Hazardous Materials Agency.

10:05 Break

IV. Research and Development, cont. - Moderator: Dr. Edward Novak, USA-CERL

- 10:20 Painting Materials and Operations at Navy Shore Activities Affected by Environmental Considerations. Dr. Richard Drisko, Naval Civil Engineering Laboratory.
- 10:45 Solvent Reclamation by Batch Distillation. Bernard Donahue, U.S. Army Construction Engineering Research Laboratory.
- 11:10 Discussion
- 11:30 Concluding Comments - Dr. Clemens Meyer, Headquarters, U.S. Army Corps of Engineers, Directorate of Research and Development

LIST OF ATTENDEES

Alfred Beitelman	USA-CERL
Armand A. Balasco	Arthur D. Little, Inc.
Itamar Bodek	Arthur D. Little, Inc.
James Booher	Letterkenny Army Depot, Chambersburg, PA
Carl D. Cole	U.S. Army Corps of Engineers, Huntsville Division, Huntsville, AL
Pat Christman	Sacramento Army Depot, Sacramento, CA
Dr. Mary C. Daly	Tobyhanna Army Depot, Tobyhanna, PA
Charles Darvin	U.S. Environmental Protection Agency, Research Triangle Park, NC
Bernard Donahue	USA-CERL
Lester E. Donelson	Letterkenny Army Depot, Chambersburg, PA
Dr. Richard D. Drisko	Naval Civil Engineering Laboratory, Port Hueneme, CA
Emmett Dunham	Enterprise Chemical Coatings, Wheeling, IL
Gary D. Ford	U.S. Army Depot Systems Command, Chambersburg, PA
Peter Goutos	Watervliet Arsenal, Watervliet, NY
Ronald M. Grant	Anniston Army Depot, Anniston, AL
Mark Groniger	Letterkenny Army Depot, Chambersburg, PA
Erik Hangeland	U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD
William Hasselkus	H.Q. Army Materiel Command, Alexandria, VA
Irl W. Hauman	Letterkenny Army Depot, Chambersburg, PA
James E. Hensley	National Guard Bureau, Aberdeen Proving Ground, MD
George M. Jonas, Jr.	Defense Reutilization and Marketing Service, Battle Creek, MI
Susan Johnston	USA-CERL
Robert Katz	U.S. Army Armament Research and Development Command, Dover, NJ
Steven Kish	Enterprise Chemical Coatings, Wheeling, IL
Robert F. Lubbert	U.S. Army Facilities Engineering Support Agency, Ft. Belvoir, VA
William McKinnery	Occusafe Inc.
Dr. Clemens Meyer	H.Q. U.S. Army Corps of Engineers, Research and Development
Walter Mikucki	USA-CERL
Jesse Neal	Air Force Engineering and Services Center, Tyndall Air Force Base, FL

LIST OF ATTENDEES (Cont'd)

John Newton	Letterkenny Army Depot, Chambersburg, PA
George Norton	U.S. Army Corps of Engineers, New England Division, Waltham, MA
Dr. Edward Novak	USA-CERL
CPT. Raymond A. Peters	Air Force Engineering and Services Center, Tyndall Air Force Base, FL
David Renard	U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD
Dr. Keturah Reinbold	USA-CERL
James A. Rittenhouse	U.S. Environmental Protection Agency, Region V, Chicago, IL
Barbara Sparks	Naval Facilities Engineering Command, Alexandria, VA
Peter Spyropoulos	U.S. Environmental Protection Agency, Region V, Chicago, IL
Sue A. Svec	Anniston Army Depot, Anniston, AL
Sharon Tipton	U.S. Army Environmental Hygiene Agency, Aberdeen Proving Agency, MD
Roger C. Wilmoth	U.S. Army Environmental Protection Agency, Water Engineering Research Laboratory, Cincinnati, OH

SESSION I.
PAINT MANUFACTURING AND USE

CURRENT TRENDS AND CONCERNS RELATING TO ENVIRONMENTAL ASPECTS OF PAINTS AND PAINT MANUFACTURING

**S. R. Kish and E. Dunham
The Enterprise Companies
Wheeling, Illinois**

Enterprise is a large manufacturer of consumer and industrial paint products, marketed nationally under four consumer-known brands, Magicolor, BPS, Enterprise and Mary Carter. Our major latex-based paint plant, warehouse and corporate offices are in Wheeling, Illinois.

We are active in four industrial market areas: Defense, Construction, Packaging and General Metals. Coatings for these markets are developed and manufactured in our Chicago plant.

Our discussion regarding current trends and concerns relating to the environment will focus on two major areas. These are:

1. The internal operational issues, and
2. The marketplace.

We will discuss the direction of new product development to satisfy the "Clean Air Act" of August 1977 and various health and safety issues. We will also discuss various Federal, State and Local regulations as they impact our manufacturing operations.

1 INTRODUCTION

We are honored to be here this morning to share with you several of the concerns of a paint company about the environmental aspects of paint and paint manufacturing. We will divide the presentation between Mr. Emmett Dunham, our Environmental Manager, and myself. I will focus more on the paint industry in general, while Emmett will be primarily concerned with our manufacturing operations.

The Paint Industry

Although the paint industry is a mature, slow growth industry, it is vitally important to all of us. Picture your automobile without paint or picture your house without paint. Not only does paint protect substrates, it provides the wonderful world of color.

The U.S. paint industry is enjoying sales of an estimated \$10 billion in 1986. The 1986 volume is forecast to be approximately 1,000,000,000 gallons. The major portion of the paints produced are categorized as architectural coatings. Architectural coatings are for the most part interior and exterior house paints. They are referred to as shelf products.

In 1986, there are an estimated 1,100 paint companies in the U.S. with an employment of approximately 54,000. Only 600 paint establishments employ over 20 people and of those, only 50 employ 250 or more. California has more paint establishments than any other state. New Jersey is second and Illinois has the third largest concentration of paint establishments.

The per capita sales of paint products in 1985 was \$41.06. In 1980, it was \$28.60. The per capita usage, however, was 4.1 gallons in 1985 and 3.9 gallons in 1980. Of the \$41.06, \$17.20 was architectural finishes, \$14.06 was industrial OEM and \$9.80 falls into the category of special purpose. This special purpose category includes those industrial paints that were not applied by the OEM. Examples would be automotive aftermarket, maintenance and marine finishes.

Enterprise

Enterprise is among the 50 firms with 250 or more employees. We believe that we are among the top 10 producers of commercial and industrial paint products. We market nationally under four consumer-known paints: Magicolor, BPS, Enterprise and Mary Carter. Our major latex based paint plant, warehouse and corporate offices are in Wheeling, Illinois. The Enterprise Companies is a wholly owned subsidiary of the Insilco Corp. of Meriden, Connecticut.

We are active in four industrial market areas: Defense, Construction, Packaging and General Materials. We are becoming active in a fifth; the exciting field of Coatings for Plastics. Coatings for these markets are developed and manufactured in our Chicago plant.

In addition to our 2 plants in the Chicago area, we have manufacturing plants in San Carlos, California, Tampa, Florida and So. Plainfield, N.J.

Paint Manufacturing

For those of you unfamiliar, you may be interested in knowing how paint is made.

Pigments and inert material are blended with various resins to produce the paint. Pigments and inert materials are received in various forms. They are dispersed in the resin using a sand mill, Hockmeyer or other types of dispensing equipment. Final shading and reducing are completed prior to filling. Quality Control plays a major part by insuring that the product is within specifications during the manufacturing operation and before filling. The paint products are filled in tankers, totes, drums, 5-gallon containers, 1-gallon containers, quarts, pints and half-pints.

2 ENTERPRISE'S OPERATIONAL ACTIVITIES

Product Development

Our concerns about the environment are many and varied. perhaps the most significant development regarding the environment for industrial paint formulators was the "Clean Air Act" of 1977. This Act caused the paint industry to concentrate on meeting compliance targets. Several options were available. Among the more popular were high solids and water reducible coatings. Today, at least 50% of our research efforts are directed toward developing compliant materials with lower VOC (Volatile Organic Compound).

Architectural finishes are not without challenges even though 80% of these finishes are latex emulsions. The remaining 20% are solvent based. Solvent based consumer paint products are coming under VOC requirements in California. In Texas, aerosol cans are not sold as off-the-shelf items.

Even water-based architectural finishes present concerns. We have stopped using mercury as a fungicide in Illinois because we are not able to discharge efficiently into the sewers.

Another example of environmental concerns affecting the paint industry is methylene chloride. This material was used in consumer spray paints. Because of potential health dangers, we have removed methylene chloride from our consumer aerosol paints.

We are spending a great amount of time and money attempting to find a substitute for methylene chloride as a paint stripper.

Another example, formaldehyde is under attack. We are studying alternate material for a bactericide in latex.

We must also be mindful of potential hazards associated with the selection of solvents. We have removed ethylene glycol mono-ethyl ether and ethylene glycol mono-ethyl ether acetate from our coatings because of potential health and safety problems.

We direct a considerable amount of effort toward anticipating actions of regulatory agencies. We cannot wait until a product has been deemed unsuitable before finding a substitute. We review journals, attend conferences sponsored by various organizations including Illinois State Chamber of Commerce, participate in trade associations such as the National Paint and Coatings Association to know the status of raw materials, legislation, etc.

In addition to our own research and development efforts toward compliant materials, we are looking toward our suppliers to advise on ways of obtaining lower and lower VOC materials.

Plant Operations

Mr. Emmett Dunham will now review our concerns as manufacturers of paint products.

We have listed acronyms that are important to our company.

RCRA	TSCA	CERCLA
FIFRA	CWA	CAA
IEPA	USEPA	NJDEP
FEDER	MSDGC	OSHA
USCG	DOT	CFD
HHE		

The first section of this list represents laws or regulations that we have to follow. The second section of the list contains a few of the organizations that we are responsible to. At the bottom of the list is a single acronym - HHE which stands for Human Health and the Environment. Protection of Human Health and the Environment is the basis for all the laws and all the organizations that are listed above.

In the course of protecting Human Health and the Environment, we protect our employees, our consumers, the community at large and the physical environment. Our employees are exposed to our materials daily. Consumers are exposed to some of the hazards that our employees are exposed to, and because we store and use hazardous materials, the community at large and the physical environment could be affected.

Right to Know

At Enterprise, we take measures to protect each of these groups. I'll begin in order of greatest or more continuous exposure. Our employees are protected legally under OSHA regulations or the Occupational Safety and Health Administration. These regulations call for a safe workplace in general and they call for a set of regulations commonly known as the "Right to Know". Under the "Right to Know" act, we are required to label our materials to inform our employees of the risk of the materials they are dealing with, we are required to obtain MSDS or Material Safety Data Sheets from our suppliers and we are required to provide the same for our customers. We are required to train our personnel in the hazards of the material that they are working with and we are required to maintain a written hazard communication plan.

Hazardous Material Information System

Appendix 1 is an explanation of the HMIS or Hazardous Material Information System. This system was designed by the National Paint and Coatings Association specifically to comply with the "Right to Know" regulations. HMIS labels express hazard to our employees by giving a number for each of three hazard classes. First one or, blue - being health hazard, second one or, red - being flammability hazard, third one or, yellow - being reactivity hazard. A numeric standard from 0 to 4 is applied to each of the three hazard categories with 0 meaning essentially no hazard and 4 meaning a severe, accute hazard. The fourth section of the label gives a letter designating the protective equipment required to protect the employee from exposure to the material.

MSDS

The Material Safety Data Sheets that we receive from our suppliers contain information in detail on the hazards associated with the materials that we use. These sheets are available to all of our personnel so that they can protect themselves from any hazards. Training required by OSHA is accomplished initially when an employee starts with us and through monthly seminars or safety meetings for all plant employees. Seminar topics include instruction on HMIS, and how to obtain MSD sheets. The written hazard communication plan is kept in our personnel office. It is required by law and it is essentially used by OSHA to determine that we are in compliance with their regulations.

The "Right to Know" requirements are only a part of our effort to maintain a safe workplace. Employee training includes safe operation of equipment, safe entry into confined spaces and safe handling of special materials. In addition to the "Right to Know" training, our employees are given physical examinations prior to employment and those employees exposed are checked annually for blood lead level.

Air Monitoring - Confined Space Entry

We conduct periodic air monitoring for specific airborne hazards and those employees exposed are given specific training in dealing with lead dust, confined space entry or safe handling of very toxic materials. Confined space entry, as an example, requires that a form be filled out for each tank entry by the employee entering the tank and signatures must be obtained from the employee, the personnel handling the life line, a process engineer, the employees supervisor and the plant manager.

Prior to tank entry, the tank has to be checked for explosives, toxic and low oxygen conditions. All mixing equipment has to be disengaged and any fill lines have to be disconnected. If air monitoring shows a hazardous condition, the employee entering the space is required to use supplied air and non-sparking tools.

Labels

We protect our customers by labeling our materials in accordance with the NPCA Labeling Guide which is at least as stringent as any federal or local regulations, by providing Material Safety Data Sheets and by providing customer assistance when requested regarding safe use and disposal of our materials.

Protection of the community at large has been a matter of concern since Bhopal. Everyone living next to a chemical processing plant has assumed that they were in grave danger. In fact, we protect the community at large, by containing all hazardous materials on site through safe operation of our plant, operation of air pollution control devices and disposal of our waste in a safe manner.

Many states, including Illinois, have passed community "Right to Know" laws requiring inventories of hazardous materials and plans for response to hazardous material spills. According to the Chicago Tribune, only 7.5% of the plants that should have reported are in compliance with the act. The Enterprise Companies plants are in that minority in compliance with this act.

Concern for the environment has been prevalent since the 1970's. We are interested in safe waste disposal since our hazardous wastes are hazardous by characteristics of ignitability. Our policy is to dispose of these wastes by incineration in one form or another. Liquid solvent wastes are sent to a reclaimer from which we receive reclaimed solvent for tank cleaning. Still bottoms from these reproprocessors are used as fuel in cement kilns. Solid hazardous wastes are disposed of at commercial incinerations. The Enterprise plants have no process discharges to waterways and no hazardous materials are discharged to sanitary sewer systems.

I would like to return the podium to Steve at this time. If you have any questions, we will both be available at the end of his presentation.

3 MARKETPLACE

Customer Health & Safety

Our responsibilities to our customers extends beyond the selling and servicing of our products. We are concerned with the health and safety of the employees working with our products at our customer locations. Through the National Paint and Coatings Association, we are structuring our labels to reflect the correct hazardous warning statements. Material Safety Data Sheets are provided to our customers.

Disposal of Paint Waste

A paint company is a generator of hazardous waste and as such is responsible forever. One of our major concerns is the final disposition of our product by our customer and the container in which it was shipped. We are concerned about the potential hazards when a customer puts toxic waste into a drum or container which, at one time, contained our paint. If this drum were to find its way into a land fill that was later found to be in violation, we are concerned about our liability.

4 SUMMARY

The concerns about the environment have resulted in the development of government regulations addressing air pollution. Because of these regulations, the technology of paint formulating has been directed toward low VOC coatings. Our company has channeled a significant portion of our R & D efforts into high solids coatings to meet various state and local compliance rules.

A second major concern is that issue of health and safety. The paint industry has been formulating away from heavy metals, i.e. lead and hexavalent chromium and solvents which are considered hazardous. In addition, we are observing many regulations regarding safe manufacturing practices.

A third issue, and one that is of growing concern, is the disposal of paint wastes...both within our company and after our paint products have been shipped to our customers.

5 OUTLOOK

We suspect that concerns for the environment in the broadest sense will require paint companies to specialize. That is so because we must become knowledgeable about the governmental regulations regarding each market segment. As a paint company, we find that each market will require a specialized type of approach.

We predict that you will see the emergence of a one or two product line paint company. Perhaps these will be smaller companies, focusing on specific marketplaces. We also predict that there will be the demise of some paint companies without deep pockets as a result of fines, penalties, heavy R & D costs, costs of staff personnel such as environmentalists, industrial hygienists, etc.

We predict that before the end of this century, every paint company is likely to find itself involved with a "super-fund" clean-up effort.

In closing, we wish to assure you that Enterprise is going to do whatever it takes to be a responsible member of our community. We have outlined our challenges and we are turning them into opportunities by committing to meet or exceed existing or potential legislation.

We will be up to this challenge and as a result, achieve our growth objectives.

On behalf of Emmett and myself, thank you for providing the opportunity to discuss our concerns about the impact of paint and paint manufacturing on the environment.

HAZARD INDEX

4 Severe Hazard

1 Slight Hazard



3 Serious Hazard

0 Minimal Hazard

2 Moderate Hazard

PERSONAL PROTECTION INDEX

A ~~BA~~

B  **+** 

C + ~~AA~~ +  + 

三 亞 十 手 十 眼

Hand + Foot + Mouth Disease

NPC/hmis.CI

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X Ask your supervisor for specialized handling directions

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Safety Glasses

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Gloves

**Synthetic
Apron**

Dust
Respirator

Vapor

Combination Dust



Full Protective



Boots

ENVIRONMENTAL CONSIDERATIONS IN THE USE OF PAINTS AND COATINGS AT U.S. ARMY INSTALLATIONS

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ABSTRACT

The purpose of this paper is to review US Army Installation responsibilities and problems related to environmental considerations in the use of paints and coatings. The Facilities Engineering Support Agency (FESA) provides professional and technical support to Directors of Engineering and Housing (DEH) at Army installations worldwide. These DEH's are responsible for the maintenance of real property and environmental management programs at the installations. Paints and coatings and related environmental considerations play an important role in the successful accomplishment of this mission. It is important for the DEH to recognize that paints and coatings and their components are potential hazardous wastes and must be managed in accordance with the installation's Hazardous Waste Management Plan (HWMP). Components of a HWMP are contained in this paper. In the future, a major concern of the DEH will be how to comply with the volatile organic compound (VOC) requirements of the Clean Air Act.

PURPOSE

The purpose of this paper is to review responsibilities and problems related to environmental considerations in the use of paints and coatings at US Army installations.

INTRODUCTION

The US Army Facilities Engineering Support Agency (FESA) located at Fort Belvoir, Virginia, has the mission of providing professional and technical support to US Army installation Commanders and Directors of Engineering and Housing (DEH).

These DEH's are responsible for the maintenance of all real property facilities at Army installations worldwide. Replacement value, not including the value of the land, is approximately \$158 billion. Over one billion square feet of buildings, plus bridges, and other structures are included. The cost to maintain these facilities amounts to more than \$800 million a year. Paints and coatings play an important role in the maintenance and repair of these facilities.

The Army leadership at all levels has expressed and demonstrated its concern for protection of the environment. From the Secretary of the Army, through command channels, to include the Army Chief of Engineers, the word has gone out to the installation Commanders and DEH's, to give high priority to all action related to environmental protection and enhancement.

FESA has assisted the DEH's in meeting some of their environmental responsibilities. Our environmental engineers have worked with the Office of the Chief of Engineers, (OCE), the Major Commands, (MACOMs), and the installations, in an effort to improve water treatment, wastewater treatment, and the elimination of environmental hazards at Army locations worldwide.

With the passage of the "Clean Air Act" of 1970, and the enactment of the "Lead-Based Paint Poisoning Prevention Act," (PL 91-695) on January 13, 1971, the DEH was introduced to the environmental concerns in the use of paints. Since that time, additional restrictions on the use of lead and mercury; the restrictions on the use of solvents; and the environmental concerns in the disposal of paint wastes have further complicated the responsibilities of the Army DEH.

The DEH has attempted to keep informed concerning environmental and all other considerations in the life cycle of paints and coatings. It has not been an easy task. The Tri-Service Technical Manual, "Paints and Protective Coatings" (Army TM 5-618), published in June 1981, identifies restrictions, but requirements have changed since 1981. We expect the new manual currently under revision will identify even more restrictions.

I welcome the opportunity to meet in a Workshop such as this with wide representation so that all phases of this complex problem can be considered. The DEH is interested in the proper concern and balance of such things as the following:

- *Environmental Regulations
- *Environmental Needs
- *Hazardous Waste Management
- *Life Cycle Costs
- *Initial Costs
- *Appearance
- *Serviceability
- *Competitive Bidding
- *Legal Requirements
- *"State-of-the-Art" Paints and Coatings Technology

RESPONSIBILITIES

Before environmental problems related to Paints and Coatings can be discussed, it is important to understand some of the responsibilities and organization at a "typical" Army installation. Below is an excerpt from Chapter 12, page 12-1 of the Draft DA Pamphlet 420-XX "Installation Commander's Executive Guide to Directorate of Engineering and Housing Operations" which overviews environmental factors:

Chapter 12 Environment.

12-1. General - Environmental laws carry both civil and criminal penalties for non-compliance and thereby require installation commander attention. One of the most demanding roles of both the installation commander and the DEH is ensuring that the installation is in compliance with the nation's environmental and natural resources laws. The intent of this chapter is not to acquaint you with all the environmental acts and directives that govern installation operation, although synopsis of several are given in this chapter. Rather, the intent is to provide you with a "feel" for the magnitude and importance of your responsibilities in these areas.

12-2. Actions Affecting the Environment - All actions must be assessed to determine the impact on the environment. The proponents of the action are responsible for the assessment, which when completed, should be reviewed by the Environmental Office. This office can provide advice on the application of environmental laws and regulations, as well as on the preparation of environmental documentation, but this office normally does not prepare the documents.

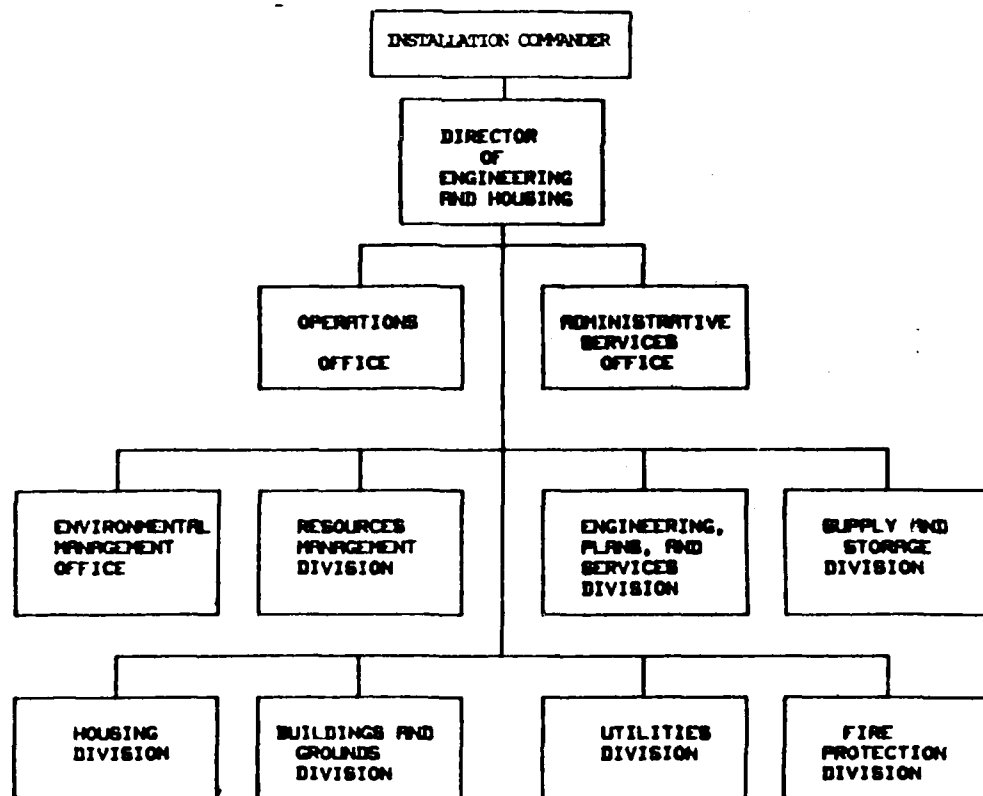
12-3. Installation Commander's Responsibility - Although the installation commander's responsibility in the environmental arena is not new, the National Environmental Policy Act of 1969 (NEPA) (42 USC 4321 et seq.) brought this responsibility into sharp focus. Subsequent environmental statutes and amendments require military installations comply with both the procedural and substantive environmental requirements of Federal, state and local governments. There is no longer any question whether non-Federal enforcers have enforcement

powers over Federal agencies and officials. Refraining from activities that degrade the environment is a key thrust of most environmental laws and is a requirement that may severely affect activities such as readiness training.

12-4. Quality of the Environment - Large amounts of resources have been expended to improve the quality of the environment at Army installations. Innovative technology has been developed to control pollutants unique to military operations. Many new industrial and municipal treatment facilities applying these technologies have been completed or are under construction. Although the Army has compiled an impressive record in abating air and water pollution, many installations are not yet in full compliance with the Clean Air Act (42 USC 1857 et seq.), Clean Water Act (33 USC 1251 et seq.), Resource Conservation and Recovery Act (RCRA) (42 USC 6901 et seq.) and other environmental laws and regulations.

DEH ORGANIZATION

At most Army installations the DEH reports directly to the Installation Commander and is responsible for management of all environmental programs. The DEH organization normally has an Environmental Management Office headed by the Installation Environmental Coordinator. The standard DEH Organization (Figure 1) is shown below:



STANDARD DEH ORGANIZATION

Figure 1.

Typical functions of the Environmental management office include:

- (1) Pollution abatement programs (e.g., air, water, ambient noise).
- (2) Hazardous and toxic materials/waste management.
- (3) Historical/archaeological preservation.
- (4) Mandatory coordination point for review of environmental assessments and impact statements.
- (5) Oil and hazardous material spill management.
- (6) Installation restoration program management.

Under certain conditions the functions of this office may be combined with the Utilities/EPs function. However, this is only if the following conditions are present: there is a minimal environmental workload, the population serviced is less than 2000, the authorized DEH personnel is less than 150, or non-governmental functions have been converted to contractor performance. However, under all conditions the Environmental Coordinator must have direct access to the DEH and if required, to the installation Commander.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

One of the most important functions of the DEH is to ensure compliance with provisions of the Resource Conservation and Recovery Act (RCRA) of 1976 and related acts such as the "Clean Air Act."

The objectives of the Act are to:

- Assure Hazardous Waste management practices are conducted in a manner which protects human health and the environment.
- Requires that hazardous waste is properly managed in the first instance, thereby reducing the need for corrective action in the future.
- Minimize the generation of hazardous waste.

By definition a "Hazardous Waste" is a solid waste or combination of which because of its quantity, concentration or physical, chemical, or characteristics may cause a present or future health or environmental problem. At an Army installation, the DEH treats paints and coatings and related products as a hazardous waste, and manages them in accordance with a hazardous waste management plan.

HAZARDOUS WASTE MANAGEMENT PLANS

The Resource Conservation and Recovery Act (RCRA) of 1976, and AR 420-47, Solid and Hazardous Waste Management, require all Army installations to develop a Hazardous Waste Management Plan (HWMP). The plan is designed to insure safe handling and disposal of hazardous materials and hazardous waste on the installation, and must be signed by the installation Commander.

Many Army installations do not have hazardous waste management plans or are in the process of developing them.

A good HMP includes:

- o Introductory and authority statements
- o Responsibility statements
- o A listing of hazardous materials used at the installation
- o A listing of hazardous wastes generated at the installation
- o Identification of all hazardous waste storage, treatment, and disposal sites on the installation
- o Deficiencies in the current management of hazardous materials or wastes and required projects and equipment to bring them into compliance
- o A waste analysis plan
- o An inspection plan
- o A training plan
- o A contingency plan
- o A closure plan
- o A Spill Control and Countermeasure Plan (SPOCP)
- o An Installation Spill Control Plan (ISCP)

FESA-EB has assisted installations in developing and/or reviewing new HMP's. FESA-EB point of contact is Mr. Brian Peckins at AUTOVON 354-6671.

The Army Materiel Command (AMC) also requires that all AMC installations which generate hazardous waste (HW) develop an installation "Hazardous Waste Minimization" (HAZMIN) Plan as a part of their HMP. The purpose of the HAZMIN Plan is to provide a specific plan of action to reduce the quantity and toxicity of hazardous waste generated at the installation. Details related to preparation of these plans may be found in the AMCEN-A CY 1986 AMC Hazardous Waste Minimization Plan dated 6 March 1986. AMC point of contact is MAJ(P) Jeremiah J. McCarthy, AUTOVON 284-7478.

CLEAN AIR ACT AND VOLATILE ORGANIC COMPOUNDS

As previously noted, the Clean Air Act of 1970 impacted the paint industry and placed restrictions on the use of solvents. This is because of the relationship between volatile organic compounds (VOC) and ozone levels in the atmosphere. Research has shown that all VOC's significantly contribute to the formation of ozone. Many urban areas of the country which contain military installations are in violation of the national ozone standards. Many regional air pollution control districts have promulgated regulations controlling the volatile organic content of paints to reduce air pollution so they can meet the Clean Air Act, National Ambient Air Quality Standards by the statutory deadline of 31 December 1987. EPA is concerned that many military installations will not meet the more stringent future standards. If EPA issues Control Technique Guidelines (CTGs) for additional source categories, such as Stage II Vapor Recovery, architectural coatings, plastic parts coating, and wood furniture finishing, a major disruption of painting operations could occur at many Army facilities.

SUMMARY AND CONCLUSION

The Army DEH's are keenly aware of their hazardous waste management problems as they relate to protection of the environment. Existing guidance is under revision to reflect the latest technological and environmental requirements. AR 200-1, "Environmental Protection and Enhancement" dated 15 June 1982 is under revision by FESA with funds from the Army Environmental office. The draft TM 5-634 "Solid and Hazardous Waste Collection and Disposal" was forwarded by FESA to OCE for printing in 1986. The National Bureau of Standards (NBS) is revising the "Paints and Protective Coatings TM" dated June 1981 and should have the draft ready for review by October 1986. In addition, a draft "Hazardous Waste Management Handbook" for US Army, Europe, will be completed early in FY87.

In conclusion, users of paints and coatings at Army installations must consider them to be a hazardous waste and include them in their hazardous waste management plans. In the future, the number of coats applied, the cost and durability of the paint, may only be minor considerations compared to the related environmental factors over the life cycle of the materials.

ENVIRONMENTAL PROBLEMS ASSOCIATED WITH PAINTING BRIDGES

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ABSTRACT

The type of bridge painting that has the most impact on the environment is the cleaning and maintenance painting of existing bridges. Newly constructed bridges are usually coated with long lasting non-toxic paint materials that will probably have little adverse impact to the environment over the life of the structure. Of all the bridge painting operations, blast cleaning with abrasives, which is the most common and most effective method of cleaning corroded bridge steel, presents the greatest potential for adverse environmental impact. In particular, the abrasive blast cleaning of bridges that have been previously painted with lead-based paints presents the greatest environmental concern. The concerns of air, water and soil contamination by lead paint blast debris were examined and the following conclusions were reached: inhalation of airborne lead is the most important air pollution concern; water pollution due to blasting does not appear to pose a serious environmental problem; soil contaminated with lead paint blast debris was found to pose the greatest long term threat to human health.

Properly drafted contract specifications should include the required level of blast debris emissions control, submission by the contractor of an environmental protection plan, and a stringent quality control program. Containment and collection methods should not be specified in the contract. They should be designed by the contractor to satisfy the contract specified level of emissions control.

Current blast debris containment and collection methods include the use of ground covers, blast enclosures, water to suppress dust, and equipment such as vacuum and centrifugal blasters. The factors that determine the choice of control methods are the complexity of the bridge structural members and the degree of protection required by the environmental setting. Although collected blast debris is not routinely tested to determine if it is hazardous, current disposal methods do not appear to be an environmental problem.

Two examples of bridge painting projects were studied: The painting of the Tobin-Mystic River bridge, which represents bridge painting in the urban setting where extreme environmental controls were required; and the painting of the Bourne and Sagamore bridges at the Cape Cod Canal, which represents bridge painting in the rural setting where less stringent environmental controls were necessary.

ENVIRONMENTAL PROBLEMS ASSOCIATED WITH PAINTING BRIDGES

INTRODUCTION

A few years ago, the National Association of Counties reported that one-third of the 233,000 bridges across the country were unsafe. (The Construction Specifier, April 1985) Congress has passed the "Surface Transportation Act" which allocates billions of dollars for the repair of these bridges. Steel corrosion caused by coating failure is a major factor in this repair work, which means that there will be many bridge painting projects coming up over the next few years. There will be the potential for environmental problems associated with painting many of these bridges. In contrast, newly constructed bridges are usually coated with long lasting non-toxic paint materials that will probably have little adverse impact on the environment over the life of the structure.

Cleaning and painting of older bridges, previously painted with lead-based paints, has the most adverse impact on the environment. This adverse impact is because of the toxicity of lead-based paint and the difficulty of bridge cleaning without contamination of the environment. Cleaning bridge surfaces by abrasive blasting is the most common and effective method of cleaning corroded steel. However, control of environmental pollution and damage during bridge blast cleaning operations involving lead-based paint will require consideration of the air, water and the land.

ENVIRONMENTAL CONCERNS

Air Pollution and Abrasive Blasting

Abrasive blast cleaning is the primary cause of air pollution in bridge painting. Blasting lead based paint introduces lead compounds into the atmosphere. Most of the lead particulates are deposited within 200 yards of the blasting operation. (Snyder, 1983) On a windy day, smaller lead particulates will be deposited at much greater distances. But, because of the dispersion of the blasting dust plume, the amount of lead deposited at any one point will be low. When blasting operations are conducted very high above the ground, as with cleaning the arch of a high bridge, transport distance and dispersion can be significantly greater.

The most important air pollution concerns of the lead-based paint blasting operation are inhalation of airborne lead and the disposition of the lead compounds deposited in the area exposed to the abrasive blasting plume. The size and health effects of the blasting dust plume can depend on the choice of blasting abrasive. Silica blast abrasive, for example, creates a large plume of very small particles that can be carried long distances. Inhalation of too much silica dust can result in negative health effects, however, no evidence of silicosis disease in blast

operations has been found when air-fed hoods are used. (EM 1110-2-3400, 1980) Also, no evidence could be found of silicosis disease in other workers or in the general population in the area of bridge blast cleaning operations. Black Beauty blast abrasive doesn't break-up as much on impact as sand and therefore creates a smaller dust plume. Air monitoring at a large, generally uncontrolled, blasting operation has shown that concentrations of particulate and lead materials are generally very low in comparison to Federal and most State ambient air quality standards. (Bareford, 1982) However, if the bridge is in an urban area, where lead levels may already be high, the addition of small amounts of additional lead to the air may create adverse health effects to those living in the area, particularly small children. (Snyder, 1983) If the bridge is in a rural area, adverse health affects due to air pollution are unlikely.

Water Pollution and Abrasive Blasting

When abrasive blasting debris is allowed to enter a water course, most of the paint debris sinks immediately. (Snyder, 1983) Some small particles may create an unsightly scum on the water surface and may travel some distance before eventually sinking. This scum is the most objectionable aspect from a water pollution standpoint. Lead paint debris allowed to fall into a water course does not appear to pose a serious environmental problem because lead based bridge paints are insoluble in water. (Snyder, 1983) However, in urban areas, where lead content in runoff from land surfaces may already be high, more stringent controls may be needed to limit the lead load.

Soil Contamination and Abrasive Blasting

Soil contamination, caused by the abrasive blasting of lead based paint is probably the greatest environmental concern of bridge painting operations. Lead can build-up over years of repainting and it will stay in soil around a bridge for thousands of years. (Snyder, 1983) Hence, levels of lead around lead painted bridges can be extremely high. Also, lead can be wind blown from off the ground to new locations and can be absorbed by vegetation. Another concern of soil contamination is that large chips of lead paint falling from a corroding bridge can pose a serious danger to children playing around the bridge, should the chips be ingested.

Soil lead levels adjacent to lead painted bridges are generally higher in urban areas than in rural areas. At the Bourne Bridge in Cape Cod Massachusetts, soil levels were found to range from approximately 100 ppm to 1,000 ppm. (Knowles, 1981) Whereas, at the Tobin-Mystic River Bridge in urban Boston soil lead levels were found to range from 1,200 to 4,800 ppm, with an average of 2,700 ppm. (Berlandi, 1982) Background level in the U.S. is around 16 ppm, and in urban areas, soils with over 500 ppm lead are common. (Snyder, 1983) Children are in the greatest danger playing where soil lead contamination is high.

IMPACT STATEMENTS AND SPECIFICATIONS

The Environmental Assessment (EA) and the Environmental Impact Statement (EIS)

The first time you may be forced to think about the environmental considerations for a bridge painting project is during the preparation or the review of the EA or EIS. Within this initial stage of the project a determination must be made as to the potential for environmental damage and what, in general terms, should be done about it.

Cooperation with the EPA, the State Environmental Quality organization and especially the local government where the project will take place is essential.

Contract Specifications

Most bridge painting projects are done by contract through open bidding. The contract specifications should cover all aspects of the painting operation, including containment and collection of blast debris, if this work is intended. However, specifications for containment and collection should be flexible. Contract specifications that require the Contractor to control emissions to a specified level, but leave the method up to the Contractor, generally produce the best results. In locations where emission controls are particularly critical, such as a bridge directly over an urban neighborhood, a two step advertised contract may provide the best results.

To ensure proper consideration of environmental protection by the Contractor, an environmental protection plan, written by the Contractor and submitted for approval, should be required in all bridge painting specifications. The plan should include a listing of all applicable Federal, State and local laws and regulations along with the proposed methods for compliance. Every aspect of the containment, collection and disposal operation should be described in detail by the Contractor and submitted to the engineer or Contracting Officer for approval.

When work at the site begins, a qualified quality control force will be needed to ensure the approved plan for environmental protection is followed. Close inspection and strong enforcement is needed for bridge painting contracts, since there is a tendency to sacrifice environmental protection in favor of higher cleaning and painting production rates.

CONTAINMENT AND RECOVERY TECHNIQUES

General

There are a variety of techniques that attempt containment and recovery of blast debris when cleaning bridges for painting. Current blast debris containment and collection methods include the use of ground covers, vacuum and centrifugal blasters, and enclosures. The factors that determine the choice of control methods are, the complexity of the bridge structural members, and the degree of protection required by the bridge setting. Generally, highly populated or urban settings should require greater emission controls than sparsely populated or rural settings. A combination of techniques used at different locations of the bridge structure usually will provide the best results.

Ground Covers and Net Liners

For small low bridges, simply covering the ground with canvas or plastic for a wide area under the bridge will collect most of the blast debris. At higher bridges, lining the safety nets with canvas will catch most of the blast debris. This technique is impractical however for the superstructure of larger bridges and is not effective in high wind. Drapes hung vertically from the sides of the bridge may help divert the blast debris downward to the canvas. Plastic filter fabric side drapes have worked well because they have excellent strength and allow some of the wind to pass through, which is important for large structures in windy locations. After the blast debris is collected in the canvas, it can be removed by a large vacuum attached to a truck.

Wet Blasting

Wet blasting is a good technique for limiting air pollution. However, adding water to the blast stream cuts down on production rates, the water and debris is very difficult to recover and water may be forced into the joints of the structure accelerating corrosion. Using water misting curtains along the sides of a bridge to suppress dust is another method to contain the debris, but collection is still a problem.

Vacuum Blasting

Small hand held vacuum blasters work well on some structures to contain and recover blast debris. Costs are high for this technique because production rates are very low. Most older bridges are constructed of box type, built-up members with many of crevices and angles. Vacuum blasters will not work on these complex structures; they work best on large flat surfaces with few angles and corners.

Centrifugal Blasters

Centrifugal blasters use rotating blades to propel the abrasive. The abrasive is retrieved and recycled. These machines are designed for large flat surfaces, such as storage tanks and don't work well on complex structures like bridges.

Blast Enclosures

Completely enclosing the blaster operator and the area to be blast cleaned is the most effective method of containment and collection. Blast enclosures must be custom designed for a particular bridge or part of a bridge. Large enclosures employ staging and corrugated steel platforms covered within heavy canvas to enclose the area. Small enclosures can be metal boxes just large enough for one person. Negative air pressure can be used to remove dust and debris from the enclosure and to help prevent the escape of dust and debris where the enclosure meets the bridge surfaces.

Properly designed blast enclosures can contain and collect 80% or more of the blast debris. In some locations the enclosure floor can be equipped with elephant trunk funnels to divert the captured debris into trucks parked below the bridge. Blast enclosures are expensive and tend to slow production rates because of the time and labor required to move them around the bridge.

New Techniques

New techniques under development include cavitation water blasting, strippable coatings, and flash blasting with intense light pulses. These new techniques do not work well. Considerable research and development is needed to improve on existing techniques and to develop new ones that are more efficient.

DISPOSAL OF LEAD CONTAMINATED BLAST ABRASIVE

In most cases, the question is whether or not collected blast abrasive and lead paint debris is a hazardous waste because of its lead content. Lead based paint wastes are not on the EPA list of designated hazardous wastes. However, there is an extraction procedure (EP) toxicity test for materials containing lead which will define a material as hazardous if the test is failed. If the material is classified as hazardous, then it must be disposed of in accordance with hazardous waste regulations. The responsibility rests with the waste generator to see that the toxicity test is performed on the collected blast debris. The EP toxicity test is not commonly done and, therefore, there is not enough data available to determine beforehand if a particular type of lead-based paint contaminated blast debris will require special disposal. However,

considering that lead is nearly immobile in soil, current disposal methods do not appear to be an environmental problem. (Snyder, 1983)

Apparently most states do not consider collected blast debris hazardous, since the lead toxicity testing is not commonly done and special disposal is not required. Massachusetts is an exception. All collected lead contaminated blast debris from state projects must be disposed of in an EPA approved hazardous waste disposal facility, which means disposal out of state because there is no in-state facility.

Cost of Containment and Collection

Generally, the cost of containment and collection increases with the amount or degree of protection provided. The most important cost factor is the cleaning production rate, or number of square feet of steel surface cleaned per hour. (Snyder, 1983)

TWO EXAMPLES OF BRIDGE PAINTING OPERATIONS WITH ENVIRONMENTAL CONTROLS

PAINTING THE TOBIN-MYSTIC RIVER BRIDGE (ENVIRONMENTAL CONTROLS IN THE URBAN SETTING)

General

This is an example of a large bridge cleaning and painting operation in a heavily populated urban area where extreme environmental controls were necessary to protect the environment and the public health.

The Tobin Bridge over the Mystic River is a Commonwealth of Massachusetts owned bridge on a major access route to the city of Boston. Rising more than 150 feet above the river, the bridge is about two miles in length. Most of this distance is viaduct passing directly through urban residential neighborhoods where some of the homes are within 50 feet of the bridge structure. Bridge construction including original painting, was completed in 1950. The paint system called for lead-based primers and alkyd top coats. Up to 1977 the bridge had been maintenance painted three or four times using open blasting and lead paint priming. (Ricci, 1986)

Environmental Concerns

In 1977, at the start of the most recent maintenance painting operation, the Massachusetts Department of Environmental Quality Engineering (DEQE) took some soil samples around the bridge and found that lead levels were extremely high. Levels tested as high as 4,800 ppm with an average of 2,700 ppm. (Berlandi, 1982)

The major source of this lead was shown to be the paint on the bridge. Blood lead levels of the population in the area were also spot checked and found to be above average. It was evident uncontrolled blasting of the bridge would have to stop. Controls would have to be developed to prevent further contamination of the soil.

Air pollution created during bridge paint removal operations is usually a problem only in the immediate vicinity of the bridge. But, since the bridge passes through heavily populated neighborhoods in close proximity to the bridge, extreme controls where necessary to limit air pollution.

Containment and Collection (Environmental Controls)

Cleaning and painting the Tobin bridge is an ongoing operation in which 100 percent of the lead paint is being removed on the outside girders, the handrails and piers of the structure using abrasive blasting. Cleaning is performed to the Near White Metal grade (SSPC SP-10) with a mil profile of approximately 2. The new paint system for these areas is lead and chromate free. (Contract Documents and Specifications for Painting of Steel Structures - Tobin Bridge)

Containment and collection is achieved by enclosing the blasting operation in a movable booth. The booth is custom designed to completely enclose one blast operator and the area to be blast cleaned. It is about 6 ft x 6 ft x 6 ft and is mounted on two wheels which ride on the top of the bridge handrail. A similar booth design is used for cleaning the bridge piers. Canvas tarpaulins and rubber flaps are used to create a good seal against the surfaces to be blasted clean. Long hoses from the ground below feed the enclosure with breathing air for the blast operator and with cleaning materials. A suction system is used to create negative air pressure within the enclosure to prevent escape of blast dust at the incomplete seal against the bridge structure and to remove the dust to a special portable wet scrubber located on the ground under the bridge. The wet scrubber removes the dust from the air stream. A single blast operator works inside the booth, which is illuminated by electric lamps. After cleaning, the area is prime painted from inside the booth and then the booth is rolled along the bridge handrail to the next area to be cleaned and painted.

This containment and collection system is 80 to 85 percent effective in capturing the airborne lead and dust from blasting; and collects almost all of the blast abrasive. Some leakage of dust occurs at the joints between the blast enclosure and the bridge structure, particularly when the blast is directed into these areas. After a trial operation at the bridge, foam padding was added on the outside of the enclosure to cut down on noise pollution.

Black beauty blasting medium was chosen for this operation because it doesn't create a silica pollution problem and because its distinctive black color makes it easy to see to clean-up should any escape to the ground below. (Ricci, 1986) Presently, no attempt is made to reclaim and reuse the blast abrasive. However, for future painting operations, consideration is being given to treating the collected spent abrasive to remove the dust and paint and recycling the abrasive back up to the enclosure. With such a system, a more expensive and effective abrasive, such as cast steel shot, could be economically used to provide less shot breakage and higher production rates.

All the blast abrasive practicable is collected, placed in stockpiles and trucked several hundred miles north to a hazardous disposal site in the State of Maine. Although the material was not technically classified as hazardous waste by Federal regulations, Massachusetts requires disposal of all such wastes in an EPA approved hazardous waste disposal facility. (Snyder, 1983)

The blasting booth works well for some parts of the bridge, but is totally impractical for cleaning and painting the arch at the center span. The extreme height, the complexity of the structure and the high winds make almost any containment method impracticable. Periodic maintenance painting of the arch has been performed by spot power tool cleaning and touch-up painting using a red lead primer and alkyd topcoat. It may seem a contradiction to put lead-based paint back on the structure, but the lead is the best primer to prevent further corrosion and the loss of even more lead to the environment.

Air Monitoring and Other Controls

During the cleaning and painting operation, high volume air quality monitors were placed in appropriate locations to continuously monitor air quality standards for total suspended particulates (TSP) and lead. Results of the monitoring show that neither the TSP nor the lead standard are being violated. (Berlandi, 1982)

Other environmental controls in place during the painting operations included the following: (Contract Documents and Specifications for Painting of Steel Structures-Tobin Bridge)

(1) Relocation of pregnant women living within 100 feet of the bridge.

(2) Baseline blood lead tests of every resident within 100 feet of the bridge with follow-up test at monthly or bimonthly intervals depending on age.

(3) Wet sweeping all paved areas within the work area at the end of each day of blasting.

(4) Unpaved areas under and around the bridge were covered and the residue collected after each work day.

(5) Removal of stockpiled blast debris daily.

(6) A Certified Industrial Hygienist was hired to supervise the environmental controls.

(7) A public demonstration of the blasting procedures and controls was given to the area residents.

(8) A telephone "hotline" was made public to take citizens complaints.

(9) Wind speed and direction was monitored to ensure escaping blast debris and paint droplets during open painting would not be blown into populated areas.

(10) A vehicle wiping station was established to remove paint droplets from contaminated automobiles.

In the land areas under the bridge where the de-leading operation is complete, all exposed lead contaminated soil directly under the bridge and up to 100 feet away is being removed to a depth of 6 inches and replaced with uncontaminated soil. (Ricci, 1986)

Environmental Regulations

With the environment controls in place during the blasting operation there is no exceeding of the federal ambient air lead standard, the annual total suspended particulate (TSP) Standards, or the 24-hr TSP standard. Local regulations required that there be no visible blast plume from the blasting operation.

Cost

Since 1977, the city of Boston has spent 13 million dollars for six different contracts to paint different parts of the bridge and it's still not finished. (Ricci, 1986) For areas where the blast enclosure was used the cost was about \$1.33/sq ft. for paint removal and containment. Approximately 1/3 of the bridge has been spot blasted and maintenance painted and approximately 1/3 has been completely de-leaded and painted. A study is ongoing to determine safe methods of containment and collection for removing the lead from the remainder of the bridge, including the metal from pans under the bridge and the bridge center span arch.

Discussion

This project represents one of the most extensive and comprehensive efforts ever undertaken to prevent adverse environmental impact from bridge painting operations. The environmental controls used on this project were not enacted to satisfy current Federal and or State regulations, but were used out of legitimate concern for the environment and the public health.

PAINTING THE BOURNE AND SAGAMORE BRIDGES (Environmental Controls in the Rural Setting)

General

This is an example of a large cleaning and painting operation in a relatively rural area where only limited environmental controls were necessary to protect the public health and the environment.

The Bourne and Sagamore Bridges provide the only highway link between Cape Cod and the mainland. For this reason, it is vital that both bridges remain in serviceable condition. Completed in 1935, the 2,384 foot long Bourne Bridge and the 1,408 foot long Sagamore Bridge both provide a 135 foot clearance above the Cape Cod Canal. These are complex structures made-up of built-up, box type members with numerous lacings and plates which are very difficult to clean properly before painting. The original painting system for the bridges called for a lead-based primer, top coated with aluminum paint. Both bridges have been maintenance painted several times by spot blast cleaning, red lead priming and aluminum top coating. In contrast to the Tobin Mystic River Bridge most of the land areas around both bridges is unpopulated.

Environmental Concerns

In 1979 a major rehabilitation of both bridges was begun including complete repainting. At that time the Massachusetts Department of Environmental Quality Engineering (DEQE) made comments on the proposed painting operation resulting from their review of the project Environmental Impact Statement. The DEQE expressed concern over possible contamination of air and soil in the immediate vicinity and recommended that adequate methods be employed to control lead emissions from the blast cleaning operation and that a lead free-coating system be applied to the bridges.

Air and Soil Monitoring

General

A lead monitoring program of soil and air was developed by the New England Division Corps of Engineers. Monitoring involved sampling air and soil before abrasive blasting to establish a baseline study and then to perform repeated sampling during the painting operation. The purpose was to determine if lead concentrations in soil and air increased and to ensure that Federal and State regulations for total suspended particulates (TSP) and for lead were not exceeded.

Soil Monitoring

Baseline soil studies showed that soil lead content decreased significantly at increasing distances from the bridges. Soil lead levels were found to range from approximately 100ppm. to 1000ppm. (Knowles, 1981) The amount of lead that can be attributed to exhaust residues contained in highway runoff is unknown. Baseline results also showed a substantial decrease in lead concentrations with increasing soil depth. Most of the lead being concentrated in the first inch of soil. (Knowles, 1981)

Soil samples were taken at various times during the cleaning and painting operations. Increases in soil lead content appeared at locations up to 280 feet from the bridge with the highest increases at about 40 feet from the bridge. (Knowles, 1981)

Air Monitoring

An air monitoring network was designed and installed surrounding the Bourne Bridge and operated continually during the blasting operations. Lead and TSP were measured by conventional high volume air samplers. Findings indicate that during the entire cleaning and painting operation there were no instances where the lead standards, annual TSP standards or the primary 24 hour TSP standard were exceeded. (Bareford, 1982)

Lead Free Painting System

A painting consultant was hired by the Corps of Engineers, New England Division to formulate a lead free coating system. The chosen system utilizes a calcium borosilicate prime coat applied to commercial blast cleaned steel (SSPC SP6) and top coated with a silicone alkyd aluminum barrier coating. (Hare, 1980) This system was chosen because of its non-toxic nature, its compatibility with the existing red lead based system and because it is relatively forgiving should the steel be poorly prepared. While the chosen system is the best of the acceptable alternatives for these particular bridges, it can not be expected to give

a service life as long as the original red-lead and aluminum system. Lead based pigments are still the best "rust inhibitive" type of primer for steel exposed to the atmosphere.

Containment and Collection (Environmental Controls)

During the major rehabilitation of the Bourne and Sagamore Bridges started in 1979, it was necessary to construct work platforms under each bridge to accomplish deck removal. These work platforms were ideally suited for enclosing on the sides with canvas to prevent the escape of blast debris and dust while blast cleaning the under sides of the bridges. Blast debris collected on the platforms was shoveled into hoppers and removed. The platforms were not completely enclosed, so some leakage of blast dust did occur.

The high arches of these bridges are complex structures made-up of box type members with numerous lacings and plates. There is presently no economically practicable method of containment when blast cleaning these arches. The best effort when painting the arches was to monitor wind speed and direction and curtail or modify blasting operations to ensure dust would not be blown into the inhabited areas on the northeast side of the bridge. Wind speed and direction were also monitored to ensure paint droplets would not be blown into inhabited areas. Application of paint by brush was used in lieu of spray painting when wind conditions threatened contamination of private property. Also, requiring the use of low pressure (40 psi) spray painting equipment has reduced the amount of overspray and wind blown paint droplets. Wiping stations were established to remove wind blown paint droplets from contaminated vehicles.

Toxic extraction procedure (EP) tests were performed on the abrasive blasting debris. The material passed the test which indicated no significant leaching potential of lead at pH 5. Collected blast debris was disposed of by placement in a Government controlled spoil area on Government land. The future disposition of this material has yet to be determined.

Environmental Regulations

Continuous air monitoring at the site showed that there were no violations of the Federal ambient air lead standards, the annual total suspended particulate (TSP) standards, or the 24 hour TSP standard. (Bareford, 1982)

During another more recent maintenance painting operation at the underside of the Bourne Bridge, the safety nets hung below were lined with a fine woven plastic filter fabric. Side drapes of the same type of fabric were hung down on the side of the bridge facing the wind. Most of the large blast debris and some of the dust is contained in this manner.

Lining the safety nets, within the filter fabric just below the arch while blast cleaning has proved ineffective because the constant wind blows the blast plume away.

Discussion

Air monitoring at these bridge painting projects has shown that air pollution standards can be met with minimal containment of blast debris at the source.

Soil monitoring at these projects has shown that the soil around older lead-base painted bridges, particularly bridges that have been maintenance painted using open blasting, is probably contaminated with high levels of lead in comparison with background levels. In a rural setting, extensive efforts to contain the lead during removal to prevent further soil contamination are probably not necessary or cost effective. However, efforts should be made to ensure that use of the land around the bridge is restricted.

Non-lead painting systems that are compatible with the existing coatings should be specified whenever practicable to maintenance paint bridges. Also, it is likely in the life cycle of the bridge structure that consideration should be given to radical blasting to remove all of the existing lead-base coating and replace it with a high performance non-toxic coating such as inorganic zinc. Once all of the lead is removed from the structure, then consideration should be given to clean-up of the lead-contaminated soil to completely eliminate the lead problem from the environment. The decision to remove the soil should be based on the extent to which high lead levels in the soil pose a threat to human health.

CONCLUSIONS

1. The bridge painting operation that presents the greatest number of environmental problems and the greatest environmental concern is the abrasive blast removal of lead-based paint. Maintenance painting of bridges coated with non-toxic paint materials will have little adverse impact to the environment over the life of the structure.
2. Environmental and health concerns when painting bridges should be greatest when operations are performed in close proximity to developed areas. This is because urban settings will already have a much higher lead level in the soil, air and water, and because of the greater potential for human contact with the lead.
3. Lead-based paint blasting containment and collection techniques should be designed to match the level of protection required by the bridge setting. Since inhalation of airborne lead is the most important air pollution concern, heavily populated or urban settings require more sophisticated containment controls than unpopulated or rural settings.

4. Air and soil monitoring before and during abrasive blasting operations can provide useful information as to the effectiveness of the containment methods employed.

5. Abrasive blast debris is not routinely checked in accordance with EPA regulations to determine if it is hazardous. However, due to the fact that lead does not tend to move in the soil, current disposal practices do not appear to present environmental problems.

6. Lead contamination of soil by bridge paint removal operations poses the greatest long term threat to human health and the environment. This is primarily because of the extremely long residence time in the soil. Even after lead-based paint on bridges is eliminated, lead residues in soil may still pose a potential threat to the environment for many years to come.

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PAINT MANUFACTURING AND USE

SESSION I DISCUSSION

(Mikucki): You've heard from the paint industry and their concerns regarding formulation. You've heard a spectrum of users representing the industrial facilities from depots. You've heard Bob Lubbert represent the troop-type installations of the Director of Engineering and Housing, and you've heard George Norton represent the segment dealing with the Civil Works activities along the way. We have a spectrum of concerns from the population aspect, the application aspect, the environmental compliance aspect, and the health and safety aspects. I am sure there are a number of burning questions that have sprung from the discussion this morning. Our speakers are available now at this point, since you have a complete picture of the user needs and requirements. I will ask you when you pose a question to identify yourself and identify the agency you are with. As you can tell from the tape recorder, we are recording and whereas the speakers are graciously providing their papers for future reference when we try to document the general tone of the discussion we are going to need some means of identification.

(Emmett Dunham, Enterprise Paint): Mr. Norton, when you were talking about lead in rivers, I'm sure that water column was not contaminated because, as you say, lead is very insoluble in water. Did you check the river bottom sediments?

(Norton): There were some studies done back in 1970, I believe, on the Cape Cod Canal and the amount of lead that was found in the bedrocks was very low. Those studies were done at some distance from the bridge and the reason they were done was primarily because of some concern that the shellfishing industry may have been affected and the area where the shellfishing takes place was actually outside the canal itself where these bridges are located. The testing is done for the purpose of seeing if there would be any adverse environmental impact to the shellfishing industry and the testing was done in the area of the shellfish and not directly where the bridge was located, which is downstream of the bridge.

(Lubbert): We are concerned with the Clean Air Act, VOC's, and protection of the ozone layer, etc. What is being done in other countries? Is the concern as great or not as great? Maybe I should direct this question to someone from the paint industry.

(Kish): I just recently started getting into that. I have a publication from Great Britain that covers the European community, and I really don't have answers for you right now. If you would like, I could give you answers later.

(Lubbert): Is the ozone layer stable over particular geographical areas or does it move?

(Mikucki): The only thing I can draw upon is the fact that they have found holes in the ozone layer, particularly down in the Antarctic. There is a British station down in Antarctica that has been monitoring for a period of time and they only recently discovered that certain times during the year a depletion, which is locally noticable, does occur. In terms of circulation, it's probable since Antarctica doesn't have very much in the way of depleting hydrocarbons being emitted and so forth. If there is some, it may have something to do with mixing the atmosphere/stratosphere or what have you. I do know that recent publications show this anomaly. The intriguing thing was that it was back-checked against satellite data and it turned out that NASA could limit the number of pieces of data that it really had to scrutinize and put in a threshold level of certain

levels of ozone concentration, and it was missing these because it appeared these were spurious data and were too low from a reckoning standpoint to be reasonable. When they went back and removed that, they found indeed that the ground observations that were being made were verified by the satellite data.

The international aspect of paints and coatings is an interesting one. In general, do the U.S. paint formulators only make paint to suit the environmental (meaning weather and temperature, etc.) conditions that exist in the country or are they international organizations that market all over the world?

(Kish): In the paint company that I've been dealing with, the paints are formulated generally for a specific industry, and I don't think that the U.S. exports many paint products to Europe or other parts of the world. The transportation costs become very great, so I'm venturing a guess when I say that most formulators are looking at the U.S. market. But in answering your question, Bob, it may be that the U.S. is in the leadership position when it comes to VOCs. I say that because our companies and contacts with other paint companies deal with technology exchanges, and in dealing with the Japanese or the Europeans, for example, the subject of high solids or low VOC coatings is really one that has never interested them. I gather that they are not operating under the same set of regulations that we are. So putting that together, I'm assuming that we're taking the leadership role in the compliance.

(Mikucki): That squares also with the chlorofluorocarbons we banned virtually unilaterally here in the U.S. several years ago which were respectively a concern for the ozone layer. Most of the Europeans never bothered to do that apparently. The question is whether our vigilance in respect to VOCs, etc. is being matched. In a way we're creating our own little "niche of clean" while everybody else is probably getting dirty. For the most part with our environmental regulations we tend to be quite a bit ahead of the rest of the countries.

(Hauman): There are some things that were going through my mind as Mr. Norton was speaking. We are heading very rapidly to a place where our information efforts are going to be completely stagnant. You are talking about environmental controls in Pennsylvania and California right now. They must be in constant contact with the environmental people who formulate their controls. What I was wondering is what are cost factors, like bridge reclamation efforts. Our control costs for our reclamation efforts are astronomical.

(Norton): The best answer from all sides is reduction at the source, where it can be accomplished. But there is a lot of talk about zero discharge and no generation of hazardous material or hazardous waste. I think that is virtually impossible. You are always going to have some waste generation, and what they are pushing us to do first is reduce waste at the source. After that, what we do with the waste is becoming a more serious problem. We do incinerate all of our waste, but there is still some ash created that cannot be incinerated. You ultimately end up burying that somewhere. You ultimately get down to a point where there is some residue from something that you throw up your hands and wonder what to do with it.

(?) How do you justify the reclamation?

(Norton): I would like to continue to respond to that question. As far as environmental controls are concerned, when painting structures like bridges, I don't want to confine it just to bridges, but there is considerable research and design needed in the field of containment and collection when blast cleaning structures like bridges. I feel confident that

when this research and design is brought to bear on a problem that there will be solutions to some of these environmental problems. The fact is that the industry just hasn't devoted much effort to containment and collection of blast debris when cleaning bridges. When this effort is expended, there will be some results. There are some new techniques that are being studied. One is cavitation blasting. They still have a problem collecting water debris, but it is a very effective method, it does give you a nice clean surface. It does take all the paint off the bridge, but there is still a problem of collecting the water after you've contaminated it with lead paint. There are methods being researched and more research is needed along those lines. It is very expensive for containment and collection, but it will get better.

(Kish): The direction toward low VOC coatings makes a lot of sense. After all, the solvent simply acts as a carrier, and it carries the material from the can to the part and transports it. In some cases, the cost of the solvent is six or seven dollars a gallon. If you can reduce the amount of solvent used, it is a much more cost-efficient system, and has been as a result of government regulations, such as the Clean Air Act, that has forced the paint industry to build up higher solid materials, which is a benefit. How high will it go ultimately? I think the level of 2.8 is achievable for topcoats and primers. Maybe even down to 2.5, but in some ways it's a definite quantity. I don't think we are there yet, but we're moving in that direction.

(Christman): The U.S. is probably ahead of a lot of countries in terms of our environmental pollution control, and I don't think we are the only ones. For example, think about the acid rain they have down there and how Canada has become very involved in that. Here recently we spent umpteen million dollars putting a pollution control plan on the Colorado River before it dumped into Mexico. We have treaties and agreements with various maritime nations about water pollution control of the oceans and things of that nature. We may be treading ahead, but we are sucking everyone else behind us. In the same respect, in terms of "are we doing something that will force us out of business some place else," we should go back to the hearings that were conducted in San Francisco. The small shops and equipment manufacturers that supply to big companies like IBM and FMC and some of these other people that make small parts at the hearing said, "You impose the \$340,000 per year rules and we are forced out of business. We are going to take our business out of Sacramento, out of the Bay Area management district and go to Reno, because Reno doesn't have the air pollution control requirements that San Francisco has." There was a heated discussion back and forth. The small industry people, like the small industry generators, are hit very hard by these kinds of regulations. What has happened in the meantime, they implemented the regulations, and the last I heard they had seen about 10 to 15 percent of the small jobs in the area had indeed gone out of business or left for other environments. That kind of goes back to the regulatory codes on the other side of the House who allow these kinds of situations, according to local conditions. We have a perfect example at the Army Depot. We got a citation from the Bay Area air quality management district. Now we are 120 miles away from them. The citation was based upon the fact that we had a contractor who was manufacturing parts as a subcontractor for the Army Depot who supposedly had specified a noncompliant coating with the Bay Area air quality management district. They came around and took citations to the Army Depot and said, "You aren't in compliance with the Bay Area regulations, therefore, here is your citation." Now we are talking about 120 miles apart. We have 6 million dollars in subcontracts is the bottom line. It turned out that we found out something more in the investigation that we had not specified a noncompliant coating. I think this is just the tip of the iceberg, because I see more and more districts in California implementing the same kind of regulations. It doesn't make any difference if you do business in Washington or if your manufacturer is in Washington if you are specifying a contract for someone else in California. You'd better not be specifying it under

noncompliance coating. The thing we were talking about a month or so earlier may not be a question of coating at this point because we are getting more compliance coatings, and it's becoming a matter of equipment to apply the coating. All of a sudden we have a rule that says we have a 65% transfer efficiency requirement as well as 420 grams/liter VOC. We don't get that with the regulations we have been using for 50 years. Now all of a sudden we have a regulation that someone turns a switch and says that as of 1 January 1986 you have to have a 65% transfer efficiency. You go look on the market for a piece of equipment that shoots 340 and you're looking at \$10,000-\$15,000 a system. If you go through the same procurement process as we do, it would take three years to get that money. So I can understand that. The other side of the coin is some testimony that was published after someone changed the hearing and somebody from the DOD stood up at a public hearing and made the statement "The DOD is not going to comply with any efforts to improve environmental management until you change the regulations." Now how do you think that went over with the regulatory officials in California? I call it Civil Air Defense.

(Christman): They can't do anything until we change the regulations, so how can we blame the regulatory officials. Here we are saying we can't do anything, we don't have any money. Congress won't give us this or give us that. On the other hand, we're saying we are not even going to ask to change the regulations. Which way do you go?

(Spyropolous): Regarding the National Air Quality Standards controlling VOCs, several of the nations in Europe and Venezuela have been working for some years to develop regulations. In fact, there is a United Nations program to support those efforts. The EPA guys have been consulting with other countries to help them do that. The EPA will provide from 3 weeks to about 6 months, in essence, to these problems.

(Mikucki): My only question to that is, is there an attempt to try to get equivalent air quality, if you will, in these countries or is it simply supporting them as they try to do something to clean up the air?

(Spyropolous): They are becoming more conscious of pollution. In answer to your question, I think in general that everybody with air quality in smaller nations with hydrocarbons that they are much behind, but they are really now catching up.

(Katz): A couple of comments to discuss. I am Bob Katz of the Army Armament Research and Development Center in Dover, New Jersey, also known as Picatinny Arsenal. One of the areas I have responsibility for is cleaning up projectiles for artillery ammunition for medium and large caliber projectiles. We have contractors all over the country, and the first one to be hit was California with the VOC situation. We went through a whole program trying to get paints and coatings industries to meet VOC requirements. We really couldn't do it without tremendous production modifications like heating equipment, drying tunnels, cooling tunnels, and so forth. The way we approached the problem in a couple of facilities was to go to the pollution control devices as a means of complying with the VOC as opposed to reformulation. Basically we put in an absorption system which worked well. Maintenance costs appeared to be low, but the initial costs were quite high. It's not unusual for a facility to be talking about several million dollars, but we found out that in order to modify the production lines, we could be talking about almost as much money. We were concerned with the possibility that the controls would be tightened still further requiring more expenditures to modify the facility. We found there were only one or two companies that would be willing to supply the material and did not want to find ourselves in a sole source situation. So our tack, in a couple of places, has been to put it in after pollution control equipment with the existing paint. As an option, which I think is generally really accepted 65% efficiency, we've been meeting

across the board with electrostatic spray equipment and the pollution control devices. We have them in several facilities.

(Peter Goutos): In New York State, which isn't too far from Pennsylvania, we've had the same type of concerns where we're being forced into positions where we may have to comply with rules and regulations that are calling for items that aren't fully developed yet. During a conference in Albany in February, I posed that same question to the New York State PEC and EPA people who were in attendance. Some of the things will be coming on in the next couple of years, but aren't fully achievable right now, but are in various stages of development. The comment that the gentlemen made to me was that they said that by calling for certain standards on certain missions, they were forcing a learning curve situation where industry then would have to catch up and present the product so it would be compatible with the regulations. If they hadn't done that then, we probably would not develop that type of product, and we wouldn't protect the environment. That doesn't help us all the time, but I would like to thank the State of California for developing lead and chromate-free car paint which we will be incorporating in New York State. Had that not been done for California's rules and regulations, we wouldn't have had the opportunity to pull those in, and we might have been in the position of dealing with problems with hazardous waste minimization for our Army guidance. That wouldn't have been an easy avenue to go.

(Mikucki): Very fine comments! We thank our speakers for developing the user needs and paint industry concerns with respect to environmental protection.

SESSION II.
REGULATIONS

RCRA WASTE PAINT REGULATIONS AND THEIR ENFORCEMENT

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Early RCRA (Resource Conservation and Recovery Act) regulatory schemes directly listed various wastes related to paint use and manufacture, (especially paint sludges, wastewaters, cleaning solvents wastes from manufacturing, etc.,) which required paint manufacturers and significant users to register as generators and/or handlers (through treatment, storage or disposal) of hazardous waste.

In 1981, new regulatory changes in RCRA were triggered by industry complaints that the categories regulated by RCRA were too broad. These changes resulted in the general suspension of listing (as hazardous waste) wastes from the use and manufacture of paints as hazardous wastes.

Since no subsequent listing action has taken place on paint wastes (to clarify their status) the RCRA enforcement perspective has shifted to regulating paint manufacturers and users through the use of the EP toxicity tests for toxic metals (often found in paints), or a consideration of the paint wastes' ignitability. If the paint waste reaches or exceeds certain levels of either hazardous waste characteristic, it is considered a hazardous waste and the handler falls under EPA regulation.

New rules proposed by the U.S. EPA would expand considerably the number of chemicals considered EP toxic--which would increase the amount of paint materials so regulated by the U.S. EPA.

1 INTRODUCTION

Since the late 1970's, the United States Environmental Protection Agency (U.S. EPA) has been directly regulating the generation, transport, treatment, storage and final disposal of hazardous solid waste in this country by means of the regulations allowed under the Resource Conservation and Recovery Act, or RCRA for short.

Congress charged the U.S. EPA with the task of identifying which wastes produced by industry and individuals were hazards to human health and the environment in general if improperly managed. This was to be accomplished in two ways:

1 - Certain hazardous characteristics were to be noted; if these characteristics were present in the waste produced by an industrial plant, the plant would be considered to be a generator of hazardous waste.

Those characteristics were:

- corrosivity (high acid or alkalinity)
- ignitability (highly volatile and flammable).
- reactivity (emits toxic gases)
- EP toxicity (high levels of certain toxic metals or organics)

The U.S. EPA then set up threshold levels for each hazardous waste characteristic; past these levels, the waste was considered to be hazardous enough to be regulated and handled in a controlled manner. In the case of EP toxicity, for example, the levels needed to be found in a waste in order to exceed the characteristic's threshold level were roughly one hundred times the top level that they could be found in ordinary drinking water.

2 - Other wastes were to be put on a list that would note them as being always considered hazardous waste, regardless of whether or not they showed one or more of the aforementioned characteristics of hazardous waste. In the U.S. EPA's view, these wastes are clearly hazardous in all cases.

To list a waste as hazardous, the U.S. EPA conducts a detailed study of the waste and how it is produced by industry; its various hazardous constituents are checked, waste production sites visited, and the wastes themselves are sampled and analyzed. This process can take years; and once the waste is listed, it can be later taken off the list or suspended indefinitely for a specific site or across the board.

2 WHAT MAKES WASTE PAINT HAZARDOUS WASTE?

In the original RCRA regulatory scheme, waste paint and wastes derived from paint production and use were to be regulated under RCRA as listed hazardous wastes; the specific listings read:

40 CFR 261.31 - Hazardous Waste From Nonspecific Sources:

F017 - Paint residues or sludges from industrial painting in the mechanical and electrical products industry.

F018 - Wastewater treatment sludge from industrial painting in the mechanical and electrical products industry.

40 CFR 261.32 - Hazardous Waste From Specific Sources:

K078 - Solvent cleaning wastes from equipment and tank cleaning from paint manufacturing.

K079 - Water or caustic cleaning wastes from equipment and tank cleaning from paint manufacturing.

K081 - Wastewater treatment sludges from paint manufacturing.

K082 - Emission control dust or sludge from paint manufacturing.

(45 Federal Register 47832-47836, July 16, 1980)

In January of 1981, the U.S. EPA decided to suspend these wastes from the general list of hazardous listed wastes. The agency had received many critical responses from industry, most of which said that an across-the-board condemnation of all paint wastes as being hazardous wastes was too broad, and included many wastes that were not specifically hazardous.

The U.S. EPA decided that further study was needed on the problem, and anticipated that the necessary study and new regulations would be ready in a few months. In the interim, paint waste that exhibited any characteristics that would make it characteristically hazardous under RCRA would still be under regulation. (46 Federal Register 4614-4619, January 16, 1981.)

Over five years later, the waste paint study and new regulations have yet to appear - and are not likely to appear in the near future. But the enforcement of RCRA regulations against waste paint handlers has continued, using the 'characteristic' definition standards of hazardous waste under the law.

3 ENFORCEMENT ACTIVITY

There have been relatively few cases dealing directly with waste paint disposal in Region Five over the years since waste paint was suspended from the listings of hazardous wastes. Far more hazardous waste cases deal with the improper handling or final disposal of waste solvents, waste-contaminated oils, and plating wastes from industry.

The waste paint cases that have arisen are very dependant on careful analysis, testing of the wastes, and accurate statements from expert witnesses, state inspectors and the like. Since the case will depend so heavily on whether the waste paint does or does not meet an objective testing criteria, all the evidence must show that these tests have been made and definitely show the waste is characteristically hazardous. If not ...

One recent case in the Region dealt with a surplus store which had bought up odd lots of scrap paints from auto manufacturers. The paints were an assortment of odd colors and types - metallic purples, lemon yellows, and the like. All were stored in drums in the store's back lot; many were open, leaking and generally showed little evidence of care.

The first inspector's report on the subject noted all these things; he added that the material was EP toxic for mercury, and many of the lacquers were considered highly volatile - and therefore hazardous for ignitability.

After the case had been referred to the U.S. EPA, it was discovered that the tests showing the paint's hazardous nature were missing or had never been taken; since, for example, all lacquers were highly volatile, the inspector assumed that these lacquers were volatile as well. Unfortunately, because of the poor handling of the paints, many of these lacquers were in such poor shape that most of the volatiles in the sludgy mass left were long gone.

Fortunately, the case was settled long before a hearing - but the lack of solid evidence that the waste paints had met the regulatory criteria for hazardous waste might have proved devastating to the government's case.

Presently, the main characteristics that have to be taken into account in waste-paint matters are:

Is the material hazardously ignitable?

Does the waste paint contain high levels of lead, mercury, chromium, cadmium, arsenic, barium, selenium or silver? That is to say, does it meet the threshold level for EP toxicity?

If so, then the waste paints are under RCRA regulations, and must be handled according to RCRA's guidelines.

4 ON THE HORIZON

The U.S. EPA has recently proposed further amendments to the list of toxic materials that, in sufficient levels, make a waste hazardous under the EP toxic characteristic. In the newly proposed rules, the levels of some of the older substances allowed are to be changed to new standards, and a large number of new substances introduced into the EP toxic standards.

Most of these new substances are solvents such as toluene, benzene, carbon tetrachloride, isobutanol, pentachlorophenol, tetrachlorethane, tetrachloroethylene and so forth. It was the U.S. EPA's desire to, through this revision of the regulations, specially include many toxic substances that easily leached into and migrated through the groundwater if they were to be disposed of by land disposal means (such as landfillings) or treated in surface impoundments. In the notes in the Federal Register notice, the paint manufacturing industry is specifically noted as being a directly affected industry by these changes. (51 Federal Register 21648-21693, June 13, 1986.) Since some of these solvents were originally part of the reason for listing paint wastes, it would seem that the EP toxicity characteristic would show up more and more as an easier standard for enforcement in waste paint matters. (45 Federal Register 47832-4, July 16, 1980).

REGULATIONS

SESSION II DISCUSSION

(Christman): Can you tell me about the 65% transfer you have plus the regulations?

(Spyropoulos): EPA does not, the states do. The states' regulations are federally approved through the permitting process and as such are enforceable by the Federal government. Usually the efficiency needed is 90% for the control process and 70% for capturing the emissions. You can combine the two and get about 63%, but that may vary from industry to industry. So for anything that is in excess of regulation, a credit would be given. Many people have come in for compliance by controlling one part of their facility and bubbling with another. If it's costly to control one area, then you may control only one portion of it, but you have to apply to the state for a bubbling and it may necessitate a supervision which will be submitted after the State approves it. It is then submitted to our office. We then process it. It takes about 14 months to complete the process. Purchase of emission credit is possible where there is higher efficiency of control in other facilities. Also within your plant you may want to shut down a portion of the facility, and then get credit for the savings of emissions that could be given for increased production in another part of the facility.

(Christman): When you talk about bubbling, are you talking about equivalence between all hydrocarbons or are you trading off methylene chloride here for toluene there? I know that on the particulate side there is a trade-off between dust control versus white air control versus some other particulates. I wondered how you handled the VOCs?

(Spyropoulos): They have to be of the same pollutant. For a bubble to be approved, the overall should be at least 10% less. It should be a benefit to the environment and should be of the same chemical composition.

(Christman): Have you run into situations yet where businesses or industries that are doing ground water cleanup are using air stripping of organic solvent contamination?

(Spyropoulos): I am not in the Water Division. Yes, that is happening and they create water pollution, but I am not familiar with the water requirements.

(Christman): There are installations in California that are cleaning ground water that has been contaminated with TCE or with dry cleaning solvent. The air stripping towers clean it. How does that impact how EPA is permitting other kinds of VOC activities?

(Spyropoulos): I am not familiar with that, but I am familiar with a similar installation though in a coke plant that has cold press coke and a lot of pollutants are delivered. The coke cooling towers produce pollutants like cyanide, ammonia, phenols and we have a requirement there that EPA will not allow transfer of the pollutants from one medium to the other--from water to air or vice versa. So if we know of such a company that is doing that, we will inform the proper division within EPA which may be affected, that will ask them to monitor or to prove that this will not take place.

(?): In your section on VOC control technologies or reformulations, one of the suggestions you make in solvent substitution is to change the solvent system to coatings with non-VOC solvents such as glycol ethers. I'm sure you're aware that we are removing certain of the glycol ethers from our paints because they are suspected carcinogens because of their toxicity. Many of the others are coming under close scrutiny for carcinogenicity.

(Spryopolous): That's right. Methylene chloride is another substance that unfortunately presently is not regulated and some industries may use this type of substance and we have no authority to stop it. EPA is presently evaluating the use of methylene chloride. They will come out very soon with requirements and then we will have the authority to prevent the usage of those substances. We try to have voluntary agreements with companies not to use it. A company in Chicago declined to have voluntary agreements. They are not in compliance because about 50% of the solvent they are using is methylene chloride. While we may have an agreement with them to eliminate it in about 6 months, after they went back and talked to their boss, they came and told us that they were not going along with the agreement. We hope this won't happen in the future.

QUESTIONS DIRECTED TO JAMES RITTENHOUSE, USEPA

(?): Can you update us on the application of the VHS model for assessing if something is hazardous? (The new levels of criteria of metals that will be applied to the toxicity.)

(Rittenhouse): Well, metal levels are going to stay pretty much the same as they have been. They are going to be reduced in some cases. It's mostly based on the drinking water standards. We're also talking about dropping it down to much lower levels for the solvent, or the reference for the substance which will result in no adverse effects in the lifetime of the exposure. Metal levels are pretty much the same as they have been. Cadmium is one part per million. Lead is 5 parts per million, mercury is 0.2 parts per million, barium 100 parts per million, silver is 5 parts per million, selenium is one part per million...it goes on from there.

(?): Several months ago there was published in the Federal Register a proposal which suggested that those levels would be a function of the waste disposal site, and you would apply a pollution factor to the leachate concentration which varies depending upon the size of the landfill. The maximum dilution factor was asymptotically reaching 32. I think these criteria reflect 100-fold drinking water levels, but there was a suggestion, a proposal that it was going to 32. I wondered if it dropped or was eliminated.

(Rittenhouse): They really haven't made any solid decision.

(Christman): Could you comment on what success you have had permitting treatment or destruction facilities?

(Rittenhouse): The best thing I can tell you is that permitting sped up considerably as it was being switched over to the State. At present the Federal EPA doesn't do practically any permitting work whatsoever. It's all been pushed over to the states. Basically, things have been going very slowly. I would say that you are probably not going to see any sort of real breakthrough on that anytime in the near future. It's going to be very slow and dragged out.

(Mikucki): On your comment about the "empty container" aspect of RCRA, there are certain portions that allow in each a residue in the bottom of a container, providing the container is empty.

(Rittenhouse): You are talking about "how clean is clean?"

(Mikucki): Well, yes. What about the disposal of the entire container and contaminants? You're talking about knocking down something like methylene chloride to 8.6 parts per million content in the waste, unless that drum sat out at 120 °F for 6 months with the bung out, odds are that residue is hazardous. Is there not a conflict between the "empty container" definition and the tightening down of the hazardous characteristics under EP toxicity?

(Rittenhouse): Yes, it seems more likely that the "empty container" rule is going to be, from what I've heard from headquarters, greatly abridged in the near future. Part of the reason for that is that they are just tightening up all over on regulations. If we're going to make this sort of thing workable, we have to go ahead and try to allow some "life time." We have a lot of barrel processors and whatnot in the Midwest. We have lots of trouble with compliance at these sites. Probably the best answer to that is that the normal chain of things is going to bring along a major change in that in the next year or so.

(Norton): The extraction procedure toxicity test for lead involves using an acid in order to determine whether or not you have more than five parts per million. Could you tell me why the acid is used when in most normal disposal operations the disposed of lead would not be coming in contact with this acid and also lead is generally insoluble in water?

(Rittenhouse): I'm afraid I cannot answer that particular question because my technical background isn't quite up to it. I'd say that as far as the acid contents, a lot of sites that we have real lead contamination problems from in this region are battery recyclers. There are problems with lead mixed in with acids. The extraction procedures are being radically changed with the new material that is coming out. They go into considerable detail about that.

(Kish): Would you please comment on the EPA's position regarding the 1,1,1,-trichloroethane and also review those solvents that are going to be proposed.

(Rittenhouse): 1,1,1-trichloroethane is 30 parts per million, 1,1,2-trichloroethane is 1.2 parts per million. We have a list of solvents and pesticides.

(Christman): Could you give me the reference?

(?): The Federal Register citation for this particular law is 51 Federal Register 21648, June 13, 1986. It's still a proposal, but it looks like it is going to go through pretty solidly as it is.

(?) In the chromium criteria, is there any discussion of going to chromium loss control?

(Rittenhouse): It is primarily hexavalent chromium that is the problem rather than trivalent chromium.

(Christman): Explain the differences between RCRA cleanup vs. CERCLA [Superfund] cleanup activities.

(Rittenhouse): The CERCLA situation basically is--a good example of this is a lead recycler that basically melts down waste batteries. In this particular situation, what happened was that they bought the site from another company that did much the same thing. The other company left behind something like 24 acres of lead dross, and when the property was bought in 1977, they didn't do anything particularly with it. Two years later, they went into Chapter 11. So as RCRA comes in 1981, we have bankruptcy with

huge piles of lead waste that they can't do anything with. Now, after some thrashing around, the superfund people got the original owner to pay for the bulk of the clean-up because obviously the bankrupt company wasn't responsible for putting the stuff there in the first place. Now the problem was that the present owner was responsible for the maintenance and upkeep and anything that they added into it. They came up with the situation since then as to anything that happened in the past to that site is Superfund's business. Anything that happens in the future, past 1981, is RCRA. Superfund basically deals with enforcement against abandoned sites where you have to get some way to clean the site up and they have to figure out who is responsible. They go through responsible partyship, they go through a very lengthy computer check of all the various people responsible and sit down with these people and say "we need to divvy this up--who is paying." It's like breaking a large check in a restaurant 200 different ways. You have to decide who had the largest share of the meal. With RCRA we're just involved with whomever is in charge of that site at that time. They don't care who was involved in the past, just who is responsible.

In a case that happened a couple of years ago, we had a situation that we had six different people who were alternately responsible. The landlord of the site, the actual owner-operator, the bank that held the mortgage, and several other involved people including the people who were involved with the bankruptcy holding for the site. We found out that the individuals who were the owners and operators had signed a lease as individuals not as officers of the corporation. They individually got sued. It's more of an immediacy situation, for we have whomever is responsible directly at the time.

(Mikucki): Getting back to containers again. Maybe you can amplify a little bit. In a typical DEH shop at an installation, they usually have paint sheds and a wide variety of different types of paint. At some point in time, I'm sure there's a check to find out if the stuff is still usable. If it's not, there might be a half a can of this, a quarter can of that, etc. Is there a provision to allow consolidation of this material before it is manifested off as hazardous material or hazardous waste? Can you do a lab pack equivalent for being able to put a whole bunch of these things into a 55 gallon drum and manifest a single drum?

(Rittenhouse): Sure. The only thing is that you have to go ahead and show the waste analysis of what the waste really is. If it started as an undifferentiated paint, it's all thrown in these big 55 gallon drums. When you go ahead and put it down on the manifest, you have to have some sort of an idea of what you have in that drum because, frankly, a lot of sites that are taking these will ask very specifically what you have and have gotten very touchy on that point.

(Mikucki): We can identify at least the military specification under which it was procured.

(Rittenhouse): No, that won't do. You have to have an idea directly of what you have there at the time. We have no idea, otherwise, what the situation is in the 55 gallon drum. We've had a lot of cases where people tried that with waste oils that have solvents in them. "When we got this, it was perfectly fine." We take examination samples and we find out this stuff has got phenol in it and other waste solvents that got mixed in with someone's crankcase drainings.

(M. Daly): If you mix solvent materials and go for an analysis, what do you want to have us look for?

(Rittenhouse): Obviously you look for the things that you have a good idea that are in there. Otherwise, it's a kind of "the skies the limit." I hate to say that because I know tests are expensive. The only thing is that for regulatory purposes we have to be kind of sticklers on the question of "you have to know what you are disposing."

(Daly): I thought the regulation read "a chemical analysis or if you had a very good idea of what was in the cans," you could use that, if it was a reliable judgement.

(?): Get a facility to accept it.

(Daly): For manifesting purposes?

(Rittenhouse): Manifesting violations are the beginning of what we actually deal with. There are very few situations where we are actually checking every single manifest that goes through. It's when we have a recurrent problem that shows up where we're saying, "This is perfectly fine, don't worry about it." Then we go back and do samples, and we find the stuff is toxic, and then we have to do something.

(Daly): Going back to the question of the dry paint cans that the remainder is stored in 55 gallon drums. Assuming that you can trace the history of those drums, the regulation does not say that you have to do an analysis. There is an "or" in there and to the best of my knowledge, it reads "or if you have a good idea of what was in there."

(Rittenhouse): I would have to go back and look for the "or" myself to be honest, but I am well aware of many situations where the case has come up and we go ahead and say "well, do you have a real grounding" and in most cases when they put something like that on a manifest, they don't have any idea, they just put it on there.

SESSION III.

PAINT FORMULATION, DISPOSAL, AND WASTE REDUCTION

**DEVELOPMENT OF VINYL PAINT SYSTEM FOR
THE U.S. ARMY CORPS OF ENGINEERS**

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Abstract

The Corps of Engineers has used solution vinyl paint to protect steel hydraulic structures immersed in inland rivers for over 30 years. These vinyls have been found to provide the optimum in long term protection of these structures. Over the years, the formulations have had to undergo numerous revisions primarily for environmental and safety considerations. This report documents the basic reasons for some of the changes.

DEVELOPMENT OF VINYL PAINT SYSTEMS FOR THE U.S. ARMY CORPS OF ENGINEERS

1. INTRODUCTION

Background

The U.S. Army Corps of Engineers currently has a paint laboratory at the Construction Engineering Research Laboratory (USA-CERL) in Champaign, Illinois. This laboratory traces its beginning back to the Rock Island, Illinois District Corps of Engineers, where, in the 1930's, the Corps was engaged in the construction of numerous navigation locks and dams along the Mississippi River from St. Louis to Minneapolis. As each of these dams were completed, it was painted with a corrosion resistant coating consisting of red lead in oil with an aluminum topcoat. It was quickly learned that although this coating was quite durable for atmospheric exposed steel, its durability on immersed steel was only a couple of years at best. Obviously repainting this districts' 3-3/4 million square feet of immersed steel lock and dam gates at this frequency constituted a full time job for several paint crews. Chemists at the Rock Island laboratory recognized the problem and took on the challenge to develop a truly durable coating system.

Initial efforts included trying numerous proprietary coatings, formulating new oleoresinous products, and testing other available generic coatings. It was first assumed that the major obstacle to coating performance was the constant immersion; however, work with coal-tar enamel indicated the problem was more complex than first anticipated. Although this coating performed well in the laboratory and on the insides of gates, it was rapidly abraded from the gates' exterior surfaces. Thus, a greatly expanded testing program was initiated.

All aspects of coating application, environment, and performance were studied in the Corps' laboratory evaluation program. Studies evaluated the environments to which the coatings would be exposed by constructing atmospheric exposure racks, piping river water into exposure tanks, and designing an underwater abrasion machine. Programs also were implemented to objectively evaluate coatings' physical properties such as strength, hardness, flexibility, blister resistance, and corrosion resistance. Only after a coating had undergone all laboratory testing, including long-term immersion in the exposure tanks, was it applied as a test coating on a hydraulic structure. This testing program evaluated hundreds of coatings prior to the initial work with vinyl solution resins in 1947.

Within a span of several years researchers concluded that vinyl coatings were greatly outperforming all other coatings under evaluation. This realization led to more research to determine which resins, pigments, plasticizers, and solvents produced the most durable vinyl coating. Many square feet of steel coated with these early vinyl coatings are still virtually 100 percent protected after more than 30 years of service. The initial formulation was refined in the late 1940's and early 1950's and was called V-766.

Formula V-766 (Early 50's)

<u>Ingredient</u>	<u>Summer, % Weight</u>	<u>Winter, % Weight</u>
Vinyl resin VYHH	8.0	9.0
Vinyl resin VMCH	8.0	9.0
Titanium Dioxide Type III	12.0	13.5
Tricresyl Phosphate	3.0	3.4
Toluene	34.5	19.7
Methyl Isobutyl Ketone (MIBK)	34.45	22.65
Methyl Ethyl Ketone (MEK)	-0-	22.65
Propylene Oxide	<u>0.05</u>	<u>.05</u>
	100.00	100.00

Thinner for both formulations

90% Toluene, 10% MIBK

At that time there were actually two formulations for each paint, a winter and a summer formulation, which could be reduced with a single thinner. These formulations remained essentially unchanged until 1973. Between 1973 and 1981 numerous changes took place in the specifications all of which were brought about by environmental regulations.

In the mid 1960's a region in southern California adopted a regulation called Rule 66. This regulation restricted the use of certain solvents which were referred to as photochemically reactive. In the V-766 formulation this regulation meant that of the total solvent makeup of the thinned paint only 20% could be branch chain ketones such as methyl isobutyl ketone (MIBK) or methyl isoamyl ketone (MIAK) or aromatics such as toluene. The only solvent which escaped regulation is the straight chain methyl ethyl ketone (MEK) comprising about 1/3 of the winter formulation solvent. Researchers assumed that regulations of the Rule 66 style would be adopted by other areas and, desiring to be a leader in the anti pollution coatings area, set to work at reformulating the paint.

In 1971 Eastman Chemical Company, a major solvent manufacturer began commercially producing a new straight chain solvent, methyl n-butyl ketone (MBK), which appeared to be the perfect answer: Environmentally, it was considered nonphotochemically reactive and therefore was not regulated; chemically, it had solvency power superior to MIBK meaning that a higher solids paint could be produced; evaporation rate was a little slower than MIBK but this could be balanced with the use of unregulated fast evaporating MEK; safety, threshold limit value was the same as MIBK and flash point was slightly higher. A single formulation could be developed which could be field thinned for summer or winter application. Field performance appeared excellent, even superior to the existing formulation. As a result the revised formulation, Formula V-766d was put into the guide specification dated June 1973.

Formula V-766d (June 73)

<u>Ingredient</u>	<u>% Weight</u>	
Vinyl resin VYHH	9.7	
Vinyl resin VMCH	9.7	
Titanium Dioxide	15.0	
Diisodecyl Phthalate	3.3	
Methyl n-Butyl Ketone (MBK)	39.3	
Methyl Ethyl Ketone (MEK)	12.0	
Toluene	11.0	
	100.00	
<u>Thinner</u>	<u>Summer</u>	<u>Winter</u>
to meet Rule 66	MBK	MEK
to reduce cost	90% Xylene	90% Toluene
	10% MBK	10% MBK

Less than a year after the guide specification was published a contract painter became ill with a nerve disorder. It was found that the illness was caused by the solvent MBK. No reference to this toxic affect had been found in the literature and later reports indicated that other acetones did not have this same toxicity.

The Corps quickly removed all paints containing MBK from their contracts and without extensive testing replaced them with temporary formulas. The V-766bT formulation was somewhat of a winter/summer combination paint containing the fast evaporating solvent MEK necessary for fast dry in the winter and the slow solvent MIAK necessary for long open time needed at higher temperatures. Because of supply shortages during this time the formulation did allow some variation in solvents and other ingredients to accomodate changing supply conditions.

Formula V-766bT (Jan 74)

<u>Ingredient</u>	<u>% Weight</u>	
Vinyl Resin VYHH	8.7	
Vinyl Resin VMCH	8.7	
Titanium Dioxide	13.3	
Diisodecyl Phthalate or		
Diocetyl Phthalate	3.0	
Toluene	27.0 max	
Methyl Isobutyl Ketone (MIBK)	13.7 min	
Methyl Isoamyl Ketone (MIAK)	19.2 max	
Methyl Ethyl Ketone (MEK)	6.4 max	
	100.0	
<u>Thinner</u>	<u>Summer</u>	<u>Winter</u>
	90% Xylene	90% Toluene
	10% MIBK	10% MIBK

Since these temporary formulations did not meet the Rule 66 requirements, research was again initiated to develop a compliance coating. In addition to the air pollution regulations two major obstacles existed. (a) It has long been known that many solvents become acidic with age. This increasing acidity has a detrimental effect on the adhesive properties of vinyl paints made with the solvents. (b) The Corps was beginning to use a vinyl zinc primer which depended on a silane to obtain adhesion. It was learned that the silane will react with many solvents thereby eliminating any adhesive qualities the chemical might otherwise have had. After extensive work it was determined that no single solvent system could meet all the criteria. The result is a dual formulation system where one formula meets the Rule 66 style air pollution requirement and a second (standard) formulation which is compatible with the zinc-rich primer.

Formulation (Jan 77)		
<u>Ingredient</u>	V-766e (AP)	V-766e
	<u>% Weight</u>	<u>% Weight</u>
Vinyl Resin VYHH	5.4	5.6
Vinyl Resin VMCH	11.1	11.6
Titanium Dioxide	12.5	13.0
Diisodecyl Phthalate	2.9	2.9
Toluene	11.2	34.7
Nitropropane (NP)	48.0	--
Methyl Ethyl Ketone (MEK)	8.7	--
Methyl Isobutyl Ketone (MIBK)	--	32.0
Ortho-Phosphoric Acid	0.2	0.2
	<u>100.0</u>	<u>100.0</u>
Low Temperature Thinner	MEK	MEK
Moderate Temperature Thinner	90%NP/10% Toluene	MIBK or MIAK

It has been found that the compliance formulation is more toxic, more expensive, has a poorer shelf stability, is more difficult to apply and provides poorer long term protection than the standard fomulation. Even with all these negative qualities the material until recently was being used by an increasing number of Corps districts even though there were no local regulations in effect to require its use. This trend changed suddenly in 1985-86 when a painter died due to excessive exposure to the nitropropane solvent. The Office of the Chief of Engineers-Safety reviewed the safety of the material as well as the safety precautions set forth in the painting guide specification. It was determined that if the guide specification were followed the material could be safely applied, however, a letter went to all

field offices emphasizing a note in the guide specification which requires the use of the standard formulation except in those areas where air pollution regulations exist. Work is currently underway to again reformulate the vinyls to meet the Rule 66 style regulations with less toxic solvents. Other research is being conducted in the area of high solids coatings to meet the more restrictive VOC requirements enacted by some regional regulatory districts.

DISPOSAL OF HAZARDOUS AND TOXIC WASTES FROM MILITARY/INDUSTRIAL PAINTING OPERATIONS

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ABSTRACT

This paper addresses the Defense Reutilization and Marketing (DRMS) program for disposal of hazardous property and specifically, paint and paint products. DRMS at Battle Creek, MI operates the program through five regional offices and many field offices. DRMS stresses waste minimization and attempts disposal of hazardous property via reuse. Several programs are operated by DRMS that allow reuse of property through reutilization in Department of Defense (DoD) transfer to another Federal agency, donation to authorized donees, or sale to the general public. DRMS also disposes of used and contaminated paint and paint products via commercial disposal contractor.

The major challenges in the disposal of paint and paint products are when nonhazardous items become contaminated with a regulated waste. Several operational avenues are available to reduce this occurrence and reduce the cost of disposal of paint and paint products. Segregation of the hazardous and nonhazardous items to prevent unnecessary contamination can be accomplished through establishment of operational procedures. Minimization of these wastes can also be accomplished through the procurement of items with nonhazardous constituents.

Defense Reutilization and Marketing Service (DRMS) is the major Department of Defense (DoD) activity charged with the disposal of toxic and hazardous wastes from military/industrial painting operations. DRMS is also responsible for disposal of other hazardous property that result from normal stock, store, and issue supplies.

DRMS is a primary level field activity of Defense Logistics Agency (DLA) and is headquartered in Battle Creek, MI. Additionally, there are five regional offices (DRMRs) located in Columbus, OH, Memphis, TN, Ogden, UT, Wiesbaden, Germany, and Honolulu, HI. Each of these regional offices is responsible for the on-going actions of the local Defense Reutilization and Marketing Offices (DRMOs) in their geographic area. The Regional Headquarters at Memphis, TN, is responsible for the southeastern part of the Continental United States. The Headquarters in Columbus, OH, is responsible for those activities in the northeastern part of the Continental United States. Ogden, UT, is responsible for those activities in the western part of the United States. This includes Alaska. Wiesbaden, Germany, is responsible for those activities in the European Theater, and Honolulu for those activities in the Pacific Theater.

The Headquarters in Battle Creek, is responsible for ensuring that proper policies and procedures are issued. Liaison is maintained with the Federal level Environmental Protection Agency (EPA) and the contracting for disposal of hazardous waste is centralized at Battle Creek. The five regions provide technical support and training to their DRMOs. They are also responsible for ensuring liaison with the state regulatory agencies. The DRMO is the focal point for the program. It is where the property is actually located. Each DRMO is a tenant on a major DoD installation. They are responsible for maintaining good liaison with their turn-in activities and ensuring that our operations are in compliance with Federal regulations, state regulations, and the site specific military regulations. The DRMS mission involves the disposal of normal supply items such as chemicals, solvents, and, of course, paint. DRMS is not responsible for the disposal of radioactive or nuclear wastes and is not involved in the installation restoration program.

As stated before, the DRMO is a tenant on a military installation. This military installation is referred to as the host activity. It is important that the host activity and the DRMO work closely to ensure the hazardous property is disposed of properly. The host installation actually generates the hazardous property and turns it in to the DRMO, either physically or paperwork only, depending on the available facilities. The DRMO accomplishes disposal for this hazardous property as well as for any other hazardous property that is

turned in by activities off the installation. This disposal can be accomplished through our reutilization, transfer, and donation cycle; through sales; or by ultimate disposal by a private contractor. The DRMO and the host activity must work as a team to accomplish this mission. The host installation is responsible for applying for the necessary permits that are needed by the DRMO and any other tenant that may be involved with hazardous property. The DRMO, as well as the other tenants, provide the supporting documentation and data that is required by the host in order to fill out the permit application. The DRMO and the host installation also work closely when the disposal contractor is working on the installation. The host environmentalist will assist in monitoring our disposal contract and help with any technical questions, and in many cases, actually co-sign some manifests. However, it is the DRMO that is responsible for providing on-site surveillance of that disposal contractor, ensuring he complies with the regulations and with the terms and conditions of the contract.

DRMS is faced with many challenges in the area of finding good disposal sites for the large amount of hazardous property that is generated, and the importance of waste minimization is quite clear. The DRMO plays a role in this by providing some incentives for minimization of the waste stream, like through the recycling programs. When property is sold, the profits are returned to the host activity to support their recycling programs. More minimization actions will be addressed later in the paper.

DRMS has two basic ways of moving property. One way to remove hazardous property is through the normal reutilization and marketing cycle which includes reutilization, transfer, donation, and sales. A distinction is made between unused and used hazardous property. Only unused hazardous property is screened for reutilization, transfer, and donation and is offered for sale. Used property is offered for reutilization and/or sales only if a known market exists. If no market exists, the property goes directly to ultimate disposal. In other words, if the "Tylenol Seal" is broken, the property goes to ultimate disposal. This action is taken to minimize the chance that potentially misidentified contaminated property is released to the general public. Hazardous property that is reutilized or sold is done so with tight controls. An internal goal has been established to remove unused hazardous property from the installation in 120 days and used property in 60 days. In many respects the reutilization and marketing cycle represent the fastest way to move property at the least cost to the Government. The property is offered for reutilization first and can be removed for beneficial use in a matter of days. A second way to remove hazardous property is through our disposal contracts. Requirements type contracts are used almost exclusively by DRMS to provide disposal for a geographic area. One requirements contract covers all DoD activities in that area. For example, one requirements contract covers all DoD activities serviced by the DRMOs in Alabama. The number of activities serviced by this requirements contract is almost 300. In a requirements type contract, general types of hazardous property are identified that will require disposal and the contractor agrees to remove these generations at a set price in 30 days or less. These types of contracts are most responsive, since after award removal can take place on a routine basis without awarding a new contract for each accumulation. Additionally, the contracts are flexible. General

hazardous wastes are identified and most property generated at an activity fits into one of those general categories or one of the miscellaneous. Several pick-up points are identified so any type of hazardous property can be picked up at any location.

The discussion will now focus directly on the disposal of paint and associated products. The figures and statistics used are from the DRMS Integrated Disposal Management System which provides automated accounting and management of DRMS assets. Most figures that will be used will be based on data from the Federal Stock Class (FSC) 8010, Paint and Varnishes. The Stock Class must be used rather than specific National Stock Numbers because many items (some estimate up to 40 percent) are turned in to the DRMO under a Local Stock Number. The item then cannot be identified as a specific item but can be related to the Stock Class. DRMS receives approximately 16,000 lines of FSC 8010 each year. Of these 60,000 lines, approximately 32 percent are either reutilized, transferred or donated. Approximately 30 percent are sold. Sales proceeds from FSC 8010 for the period of 1 Oct 85 through 1 Aug 86 were almost \$75,000. The remainder were disposed of by service contract.

As stated, over 60 percent of the FSC 8010 are removed for beneficial reuse either through reutilization, transfer, donation, or sales. The items that require service contracting are normally used and heavily contaminated. For example, after an aircraft has been stripped, the used cleaning solvent and the paint chips would be turned in to the DRMO with a Local Stock Number identifying them as FSC 8010. Therefore, the disposal of new, unused, or uncontaminated paint does not pose a particular problem to DRMS. Some impediments to R/T/D/S of even unused paint include paints with hazardous characteristics such as lead base or organotin; or the packaging has been opened and the "Tylenol Seal" policy may be in effect; or because the shelf life has expired.

Although the disposal of paint is normally not a challenge, one incident did in fact cause the disposal of normal paint to be a major issue. The Air Force retrogrades hazardous property out of Greenland on a yearly basis. The inventory is normally PCB items and the remainder are usable items that go to a DRMO in CONUS to be subjected to the normal DRMS cycle. On the last shipment, the Air Force added 817 five-gallon cans of paint overpacked in 150 85-gallon overpacks. The paint cans were leaking and in such poor condition that disposal via service contract was considered to be the most viable option. The disposal contractor in CONUS agreed to dispose of the paint, but requested the chemical constituents and the contaminants. This request was relayed to Greenland. Unfortunately, all the paint cans were labeled in Danish. In what can be considered an innovative approach, the DRMO chief called upon her native Dane husband who agreed to read the labels and was able to provide the necessary information.

The ultimate disposal of used paint and associated products is normally accomplished in one of three ways. Some paint or paint by-products are beneficially reused by the contractor; some are solidified and landfilled; in some cases the liquid is used in solvent recovery and the sludge is solidified and landfilled.

The two-phase paint (i.e., liquid and sludge) provides the most difficult disposal challenge since more handling is required, the amount of solvent recycling potential must be determined, and the sludge must still undergo solidification for burial. The average disposal price is approximately \$3.00 per gallon. These disposal costs have been and are currently borne by DRMS. As of 1 Oct 86, the military services will be responsible for funding for disposal. The need for waste minimization is apparent.

The DRMS cycle is in itself a waste minimization program. Each of the Services also have active programs. However, these service programs are targeted for 1990 or 1992 and do not specifically address paint or associated products. There are several actions that can be taken to minimize the amount of paint and associated products that become hazardous. Obviously, the procurement of such product without hazardous constituents is a basic first step. For example, many products used for paint stripping have hazardous waste characteristics. When used on nonhazardous paint, the entire commingled residue becomes a hazardous waste for disposal. If a different stripping agent is used, such as glass beads or rice hulls, the entire commingled residue is nonhazardous. Procurement actions should include for nonhazardous substitutes and reduce the amount of lead base paint or associated products with hazardous characteristics that are procured by DoD.

There are many operational actions that can also be taken to minimize the amount of hazardous wastes generated by DoD. Commingling of empty paint cans and other empty cans, such as empty solvent cans, causes the entire accumulation to either be segregated or treated as a hazardous waste. Many DRMS contracts provide for a dumpster for empty paint cans. This dumpster does not have to be handled as a hazardous waste. However, if other cans are commingled and some have hazardous waste residues, the entire dumpster is contaminated. Proper education of personnel and establishment of strict operational procedures would reduce the likelihood of the contamination, and thereby is a waste reduction effort.

Proper identification of turn-ins, to include items such as paint strippers and thinners, is necessary for proper disposal. The chemical constituent must be identified as well as the contaminants. If proper controls are not established while the product is in use, then the contaminants are not known when the item is ready for turn in. Then the worst case must be assumed and the item must be treated as a hazardous waste. A corollary effort is to ensure that while the item is in use it is not unnecessarily contaminated with a waste. For example, a common collection tank for a nonhazardous solvent and an F series solvent will result in the entire tank being disposed of as a hazardous waste. This scenario is further compounded since the new regulations will not allow land disposal of an F series solvent. A more expensive method of disposal such as incineration is then required.

A final operational consideration is one which will not really minimize the waste generation but will reduce the disposal costs. In many paint stripping or cleaning processes, the used stripper or cleaner must be removed from the on-line process in an extremely short timeframe (i.e., 24-48 hours) in order to introduce unused strippers and keep the line operational. These short removal timeframes cause the disposal price to be higher since mobilization costs are included. If the used products could be released to a holding tank that is not directly linked to the process line, longer pickup timeframes would be acceptable and the prices would be reduced.

In summary, DRMS disposes of many paints and associated products. Many are beneficially reused and can be considered a waste minimization effort. Additional efforts are needed by the turn-in activity to reduce the generation of hazardous wastes both through procurement of nonhazardous substitutes and through operational actions.

AMC HAZARDOUS WASTE REDUCTION APPROACH AND PROGRESS

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ABSTRACT

The Army Materiel Command (AMC) is the Army's industrial command. Its mission is to support the soldier and the total Army. In fiscal 1985 it processed over 5 million requisitions, and overhauled or repaired 542,000 pieces of equipment at its repair facilities.

In September 1985, the AMC Commanding General directed his Engineer to develop an action plan which would consolidate, expand, and support the hazardous waste (HW) reduction efforts AMC installations were employing. This plan, titled the AMC Hazardous Waste Minimization (HAZMIN) Plan, was completed in March 1986. It outlines what actions AMC will take to minimize its HW generation, and how it will manage the waste it does generate.

AMC's formal HAZMIN effort is now beyond the planning phase. The Commanding General, AMC, has added HAZMIN progress to his briefing agenda during his installation visits. The HQ AMC HAZMIN Board is formally established and is addressing difficult and pragmatic issues involving HW reduction in the command. Most installation HAZMIN Plans have been completed and are in the process of being reviewed and modified if necessary to insure their viability. Installation projects reflect the diversity of AMC industrial operations. The HW reduction actions AMC has taken to September 1986 are summarized.

1 INTRODUCTION TO THE ARMY MATERIAL COMMAND (AMC)

The AMC mission is to support the soldier and the total Army, including active Army, National Guard and Reserve. AMC responsibilities are summarized in Table I. To meet them, AMC and its 10 major subordinate commands (MSC) manage 65 installations and 18 subinstallations world wide, covering 4.4 million acres of real estate. In fiscal 1985, AMC processed over 5 million requisitions, overhauled and repaired 542,000 pieces of equipment at its maintenance depots and repair facilities (AMC Command Overview, 1986).

AMC's largest MSC generating hazardous waste (HW) is the US Army Armament, Munitions and Chemical Command. This command executes AMC's responsibilities for conventional ammunition, and includes 4 arsenals and 28 ammunition plants. The second largest MSC, the US Army Depot System Command, provides centralized management of 12 primary and 5 secondary supply and maintenance depots. Two other MSC's generate significant amounts of HW: the US Army Aviation Systems Command develops and supports all types of Army aircraft, including rotary wing and fixed wing; the US Army Tank-Automotive Command is responsible for all tracked and wheeled vehicles to include construction and material-handling equipment.

Table I AMC Responsibilities

- * Research, development, and acquisition of army materiel
 - * Readiness of materiel in the hands of the troops
 - * Readiness of war reserve
 - * Department of the Army (DA) executive agent for security assistance (Foreign Military Sales)
 - * Department of Defense (DOD) executive director for conventional ammunition
 - * DA executive director for test, measurement, and diagnostic equipment
 - * DOD lead agency for chemical, biological, and radiological defense materiel development programs
-

2 AMC HAZARDOUS WASTE GENERATION

AMC's HW generation during calendar year (CY) 1985 is summarized in Table II. The largest category is unusable and discarded ammunition destroyed at demilitarization facilities such as open burning grounds and detonation areas, or in a deactivation furnace. AMC's second largest HW generation category is sludges which are generated during various industrial operations and at waste treatment plants. The distant third largest HW generation category is "other"

wastes which are principally other industrial operation by-products or side streams, and RDT&E/laboratory spent chemicals and wastes. Spent solvents from AMC's cleaning, degreasing and paint stripping operations, and heavy metal electroplating wastes comprise the smallest generation categories.

Table II AMC Hazardous Waste Generation During 1985
(millions of kilograms)

Ammunition Demil	Solvent Wastes	Plating Wastes	Sludges	Other Wastes	Total HW Generated
44.5	3.6	3.4	38.1	4.7	94.3

3 AMC HAZARDOUS WASTE MINIMIZATION

Since February 1983, AMC has formally listed as its first HW management priority the reduction of HW by use of alternative materials, in-process recycling, and reuse. Other HW management priorities have been, in descending order: segregation and concentration of HW, resource recovery, destruction by incineration, detoxification and neutralization, and lastly, landfill disposal (AR 200-1 and the AMC supplement). In addition, AMC's environmental research and development work has historically included tasks addressing recycle or reuse of AMC wastes and byproducts.

While progress was made at the local level to reduce HW, daily environmental work concentrated on meeting RCRA's HW identification, management and permitting requirements (FY 85 AMC Historical Review). EPA's 1985 regulations added additional HW management criteria (Federal Register, 15 July 1985). One requirement was for the HW generator (the installation commander) to certify in writing he had "a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and I have selected the method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment".

In September 1985, General Thompson directed the AMC Engineer to develop a comprehensive hazardous waste plan for the AMC (Trip Report, September 1985). In November, the General issued policy to the field about the need to reduce HW volume and toxicity in a practical and economical manner, and stressed the importance of addressing hazardous waste minimization in all AMC's support efforts (Commanding General message, November 1985). These two events served to centralize and prioritize AMC's present hazardous waste minimization effort. AMC's Hazardous Waste Minimization (HAZMIN) Plan was finalized and issued on 6 March 1986.

4 THE AMC HAZMIN PLAN

The AMC HAZMIN Plan outlines the actions that AMC will take to reduce its HW generation and how it will manage the HW it does generate. It consolidates and expands the HW reduction efforts many AMC installations are already employing. It contains these key elements designed to enhance its effectiveness as a plan of action to reduce HW:

- Measureable goals using well defined HW generation units and a baseline;
- Specific responsibilities for key players;
- Prioritized HW reduction methods (HAZMIN Elements);
- A common installation HAZMIN Plan format;
- A strong HAZMIN support base;
- Specific milestones for key HW reduction actions;
- Flexibility to incorporate changing conditions.

The AMC Plan takes the approach that the most effective way to manage HW is to reduce or eliminate it altogether. While elimination of HW cannot be accomplished in an industrial command such as AMC, the "before the fact" approach to HW management represents a significant departure from the historical emphasis on managing HW after generation by treatment or disposal.

5 HAZMIN GOALS

The general AMC HAZMIN goal is to eliminate disposal of all untreated HW by 1992 by reducing HW generation to the maximum extent economically practicable and managing what HW is generated in a manner minimizing any threat to our health or the environment. This goal reflects EPA regulatory requirements and DOD Policy (DOD Policy, July 1985). AMC's overall HW reduction goal is to reduce its HW generation 50% by 1992 compared to 1985 levels. Specific AMC process oriented goals are in Table III. Available technology, potential funding, and unique process/operational conditions or characteristics were considered in a series of meetings with various AMC elements to come to a reasonable conclusion about what was "economically practicable".

HW generation is measured as kilograms per year, or kilograms per year per unit of output which recognizes changes in production rates. The 1985 baseline used for progress measurement is the EPA March 1986 Biennial Report (or state equivalent) due the regulator by every HW generator and which summarizes his 1985 HW generation quantities in accordance with the HW types defined by EPA (40 CFR 261). In addition, used oil (soon expected to be regulated) is also tracked.

Table III AMC Hazardous Waste Reduction Goals

PROCESS, OPERATION OR CONDITION	PERCENT HW REDUCTION DESIRED BY 1992
Electroplating	50%
Paint stripping, solvents	40%
Paint stripping, plastic beads	60%
Painting	50%
Cleaning/degreasing	40%
Transportation vehicle maintenance	30%
Electrical maintainance	60%
Metal working	15%
Fueling operations	30%
Battery shop operations	50%
Propellant/explosive/pyrotechnic production	35%
Munitions demilitarization	40%
Load, assembly and pack operations	15%
Waste treatment sludges	60%
Other treatment-generated HW	40%
Other operations or process HW	40%

6 HAZMIN RESPONSIBILITIES

Responsibility to minimize HW generation is given to:

- The Commanding General AMC and the commanders of the MSC to provide guidance, support, problem definition, and technical assistance as appropriate to the HW generating installations;
- The commanders of AMC's primary environmental research organizations to identify HAZMIN technologies, processes or techniques which can be implemented within 5 years that will reduce HW generation;
- The commander of the AMC Installations and Services Activity to provide technical assistance and review of HAZMIN projects.
- The commanders of AMC HW generating installations to develop their site-specific installation HAZMIN Plan.

7 HAZMIN ELEMENTS

The AMC HAZMIN Plan discusses several common methods to reduce HW generation. The prioritized methods of Table IV favor managing HW before rather than after generation. This approach is significant because it requires participation by offices and disciplines historically not directly concerned with HW. As a result, it is expected that successful HAZMIN actions at AMC will increase production rates, improve output quality, reduce costs, and/or decrease manpower requirements.

Table IV. HAZMIN Elements (Prioritized)

- | | |
|-------------------------------|-------------------------|
| 1. Hazardous material control | 5. Recycle/reuse/resell |
| 2. Delisting | 6. Treatment |
| 3. Material substitution | 7. Destruction |
| 4. Process change | 8. Disposal |
-

8 INSTALLATION HAZMIN PLANS

Table V gives the format specified in the AMC HAZMIN Plan for installation site-specific HAZMIN Plans. The format contains the elements considered necessary to properly develop a local HAZMIN program. Installations can supplement the format if desired. The HW generation reports are critical planning elements. The difference between the 1985 HW generation data and subsequent and annualized semiannual HW reports will be used to measure percent HW reduction for comparison against AMC goals.

Table V. Installation HAZMIN Plan Format

- | | |
|-----------------------|---------------------------|
| a. Purpose | g. HAZMIN actions |
| b. Scope | -General |
| c. Background | -Current projects |
| d. Goals | -Proposed projects |
| e. Program management | h. HW Generation Reports |
| f. Training | -HW baseline data (1985) |
| | -Semiannual HW generation |
-

9 HAZMIN SUPPORT

Present actions supporting AMC's HAZMIN effort include installation assistance to increase solvent reuse and electroplating waste reduction, a study assessing AMC's overall HAZMIN situation (problem definition study), and studies identifying expedient technologies or techniques which can most effectively be used by AMC. The study reports, due 30 September, will help guide AMC where to best invest its funds and provide most "bang for the buck". Traditional incentives such as command emphasis, institutional awards, personal recognition and productivity incentives are being used or explored.

An AMC HAZMIN Board, composed of key HQ staff elements, provides overall guidance and direction for the AMC HAZMIN program. Board composition and interests are in Table VI. The AMC HAZMIN Board affords AMC the potential to widen its HW reduction efforts beyond the relatively narrow environmental engineering "after the fact" HW concerns. Hazardous waste reduction will be addressed from production, maintenance, and operational perspectives.

Table VI. AMC HAZMIN Board

OFFICE	HAZMIN AREAS OF INTEREST
Engineer (Chairman)	Environmental quality
Procurement	Procurement and contracting policies and specifications
Supply, Maintenance and Transportation	Supply, storage, maintenance, distribution and disposal
Development, Engineering and Acquisition	Acquisition and performance policy and procedures
Resource Management	Budgeting, economic analysis and productivity improvement
Chemical and Nuclear Matters	Munitions demilitarization
Production	Production engineering and planning, technology transfer
Technology Planning and Management	RDT&E, DOD/industry technology transfer
Surgeon	Environmental health
Personnel	Training
Safety	Occupational safety and hazard communication
Command Counsel	Environmental law

RDT&E for pollution abatement and control has been conducted by AMC for many years. AMC's interest in this area is Army-unique or Army-pervasive contaminants which have not been studied adequately elsewhere. Of the 35 active environmental research projects at this writing, ten can readily be categorized as HAZMIN R&D efforts. They are listed in Table VII.

Table VII. HAZMIN Environmental Research and Development
(Current active projects)

Reuse and Recovery Technology for Energetic Material
 Detonator Waste Heavy Metal Recovery
 Use of Industrial Boilers for Burning Hazardous Materials
 Recovery and Recycle of Waste TNT
 Propellant Reuse Technology Assessment
 Alternatives to Toxic Organic Paint Strippers
 Reduction of Total Toxic Organics and Volatile Organic Carbon
 Emissions Using Plastic Bead Cleaning
 Relationship Between Explosive Contaminated Sludge Components
 and Reactivity
 Preventive Environmental Technology for Testing and Training
 Treatment Technology Development for AMC Contaminated Solid Wastes

10 MILESTONES

AMC HAZMIN Plan milestones extend to August 1987. They will be reviewed and updated routinely. Important actions tracked include: installation baseline data compiled and local HAZMIN Plan completed by 2 June 86; overall AMC HAZMIN problem definition and technology assessment reports completed by 30 September 86; first semiannual HW generation report compiled 1 March 87; current phase of contractor technical assistance completed 30 March 87; updated (1987) AMC HAZMIN Plan completed 30 April 87; second semiannual HW generation report compiled 1 August 87.

11 FLEXIBILITY

The AMC HAZMIN Plan has built-in flexibility because conditions change and the Plan must be dynamic to be most useful. Changes to environmental laws and regulations will occur. AMC is constantly dealing with varying production and maintenance demands to provide optimum support to the soldier. The AMC Plan is designed to take advantage of new information acquired. It can be supplemented at any time and must be formally updated once a year.

12 PROGRESS TO DATE

The first measurement of HW reduction progress at AMC will not occur until after 1 March 87 when AMC HW generation for CY 1985 will be compared to CY 1986 figures. AMC continues to make progress towards consolidating and expanding its HW reduction efforts in other areas to include:

Command Emphasis

Installations have been instructed to include in their Commanding General briefing agendas the actions they are taking to reduce their HW generation (letter from AMC Chief of Staff, July 86). Requiring installations to brief their HAZMIN progress to the Commanding General during his many field trips places added emphasis on waste reduction and the importance he places on tangible results in this area.

HAZMIN Board Actions

Initial efforts addressed identifying action officers to represent the office chiefs who make up Board membership, and formalizing the AMC circular which defines Board purpose and membership. The AMC HAZMIN Board has met three times since March. One of the Board's first actions was to set yearly hazardous waste reduction goals to reach the overall 50% goal for 1992.

HQ HAZMIN Support Plans are being written by each represented office which delineate the support they will provide to the field. These support plans are one page or less and to the point: They contain a general functions statement and a list of specific initiatives being taken to implement them.

Other topics currently being addressed by the Board include: the plausibility and appropriateness of selected AMC HW reduction goals; the method of tracking HW from AMC's demilitarization efforts; depot maintenance work requirements and their modification; and HAZMIN project funding issues. A special Incentives Working Group has already been formed to allow detailed consideration of specific actions in this area.

Installation HAZMIN Plans

Fifty-seven installations have submitted HAZMIN Plans or have been accounted for. Thirteen of these installations require no formal HAZMIN Plan because they generate less than 100 kg of HW per month. Eight installations have not submitted their HAZMIN Plan as of 1 September, and efforts continue to finalize and obtain them.

Not surprisingly, quality varies widely among the installation Plans. Content varies from detailed, viable, site-specific planning to a repeat of much of the AMC Plan wording. This latter approach is not acceptable because the purpose of the AMC overall HAZMIN Plan (policy and guidance) and the local installation Plan (a plan of action) are quite different.

Other general comments are: while potential HAZMIN projects are numerous, specifics such as concise project definition, costs, and priorities are frequently not given; installation training, almost without exception, involves detailed hazardous waste management training but lacks hazardous waste minimization input; with a few vociferous exceptions, the process-specific HAZMIN goals advocated in the AMC HAZMIN Plan were accepted with little comment by most installations. The feedback provided to HQ AMC by the installation HAZMIN Plans is very valuable because as a whole it identifies areas where concentrated efforts will keep AMC's HAZMIN initiative viable and on track.

Nineteen of the 44 HAZMIN Plans reviewed were judged not acceptable for the various reasons summarized in Table VIII. Rationale is:

- Project Listing. Local HAZMIN projects represent the actions the installations take to reduce their HW generation. When no current projects were listed, the installation Plan was considered poor. When no future projects were defined (rhetoric did not qualify), the installation Plan was considered not acceptable.

- Baseline Data. The AMC HAZMIN Plan describes a measured program for HW reduction and the installation's 1985 HW generation is the bench mark. All installations will be compared against goals. No baseline data is not acceptable.

- Format/Content. The format specified for installation HAZMIN Plans is considered necessary to describe and specify a viable means to reduce the quantity and toxicity of HW generated at the installation. When installations did not include the subject areas of Table V, their Plan was considered not acceptable.

- HW Management Board/AR 420-47. AMC's HAZMIN effort is a subset of its overall HW management effort as defined in Army Regulation 420-47. An integral part of this regulation is the installation HW Management Board. When an installation Plan did not reference the AR or include an HW Management Board in its program management description, it was considered not acceptable.

-Other. Obvious reasons were categorized under this and the reasons for nonacceptability were given to the installation. Typically the Plan was too general, too brief, or no goals were listed.

Table VIII. Frequency of Reasons for Installation HAZMIN Plan Non Acceptance*

REASON	FREQUENCY
Project Listing	17
Baseline Data	9
Format/Content	7
HW Management Board/AR 420-47	6
Other	14

*From 19 installations. Non-acceptance could be for several reasons.

Installation HAZMIN Projects

The Used Solvent Elimination (USE) Program initiated in July 1984 is an integral part of AMC's HAZMIN Program. Not surprisingly, projects to reduce disposal of spent organic solvents by process change, material substitution, or redistillation are the most common projects listed in the installation Plans. Other projects reflect the nature of AMC industrial operations: projects to substitute, minimize, or delist HW generated by AMC's plating and painting operations; projects to dewater various sludges; projects in various stages to reuse and reduce wastes from its pyrotechnic, explosive, and propellant production operations. These latter efforts represent the field testing and demonstration examples of AMC's R&D program.

13 SUMMARY

AMC has initiated an aggressive and ambitious program to reduce its HW generation by 50% in 1992 over 1985 levels. It recognizes that HW reduction involves more than the historical "end of pipe" management by the plant engineer, and that HW reduction must be addressed by all activities that carry out AMC's support mission.

AMC's formal HAZMIN effort is now beyond the planning phase. The Commanding General has added HAZMIN progress to his briefing agenda during his installation visits. The HQ AMC HAZMIN Board is formally established and is addressing difficult and pragmatic issues involving HW reduction tracking and implementation in the command. Most installation HAZMIN Plans have been written and are in the process of being reviewed and redone if necessary according to established criteria. The local ongoing or proposed HAZMIN projects reflect the diversity of AMC industrial operations. AMC will be able to measure its first year HW reduction progress after 1 March 1987. The results will be followed with considerable interest by many.

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PAINT FORMULATION, DISPOSAL, AND WASTE REDUCTION

SESSION III DISCUSSION

(?): Starting 1 October the services will pay for disposal. How will that work?

(Hasselkus): Right now what's going to happen is, I don't know about the other services, but for the Army the Army's Secretary and staff are programming for that and will skim money off the top to pay Battle Creek. So you don't have to do anything in Fiscal 87 at an installation level, or at a subordinate command level, or us for that matter. Starting thereafter there is going to be something happening that you will get budget cuttings on how you are supposed to program.

(Donahue): I think that's the main disadvantage for the program to work. The activity that generates that couldn't care less.

(Hasselkus): The problem is that if you make a change like that on a relatively short notice, you haven't got time to fix it the next fiscal year. There just isn't any way to get in the budget cycle, so the Army had to take a stop-gap measure, and they recognize that fact too. Starting in Fiscal 88, which is the next year that we can reasonably expect to program in, you, the installations, will program. We'll get guidance set as soon as we get some. Right now, again budget guidance doesn't come too good in this arena. We are in the process of staffing a paper backup through our comptroller to the Comptroller of the Army. A lot of times we don't get adequate formal budget guidance as to what we are supposed to do down here and how we are supposed to program. Would you kindly tell us? Since the Defense Environmental Restoration Account has come to pass, as far as we're concerned, we've never really gotten a piece of formal budget guidance to tell us what we're going to get next year. All I get is from the functional counterpart what he thinks. That's what we have to go on. It's just not there, not since 1984.

(Moderator, Erik Hangeland): I'd like to thank our last three speakers today, particularly Mr. Hasselkus, who made a special effort to be with us. We appreciate that. Does anyone have any questions at all over the last three talks--paint formulation, disposal, or hazardous waste minimization.

(Mikucki): I understand the general process of "if you can't take care of it in a host country, retrograde it. I know that we ran into problems with that and had to improvise. It's started somewhere between the foreign shore and the U.S. shore because it was supposedly not going to be allowed back in. Is this a unique commodity or are we running into this on a substantial basis where they originally came from us, and can't get back in our door either.

(?): They are back. They are being incinerated at all our depots.

(Hangeland): Anybody else?

(Dunham): It looks like the Army is doing a lot of burying of hazardous waste. Why don't they incinerate more of their paint and incinerable waste?

(Jonas): Our approach to disposal contracting has been one of "whatever is consistent with the law of the land." We are driven by Federal acquisition regulations which say essentially that we will give it to the lowest responsible bidder. There is only one time that we have gone against that, that was with the DDT. We got rid of some 2 million

pounds of DDT. We insist on those liquids being incinerated. Generally, if I chose, using the mission statement, we are torn between doing the environmentally prudent thing as well as the economic aspect. To the extent that landfilling is permitted, I see a new advantage developing here. Some contractors would protest the landfill lengthy process.

(Dunham): Our company has made a commitment that landfilling is not necessarily responsible when you are dealing with an ignitable waste. Could you go that way? In light of CERCLA, it doesn't make a lot of sense.

(Jonas): Sure it does. I'm not sure we have enough in the treasury right now to accommodate what has already been accumulated annually.

(Dunham): It would only double your cost.

(Jonas): That is a consideration that we have to go through. There's no question, landfill is such a long-term storage and I'm not sure what long is, in this instance.

(?): If incineration seems to be the way to go on a lot of organics, instead of the Army always subcontracting that out, have they ever looked into setting up their own hazardous waste incineration facilities?

(Jonas): We are working closely with all of the services. The Army depots are incinerating the ammo boxes. We are also working with Pine Bluff. We've got a Catch 22 on a number of product commodities that the regulatory community is forcing a Catch 22 if you will. I can give you a couple of examples: Foreign made PCBs cannot be brought back to the U.S. In countries that do not have the technology to rid themselves of them, lithium-carbon oxide batteries are another example. DOD will not allow them to be brought by air or by water. If they are overseas, I don't know how else we could get them back. We're working with the services. Quite frankly we have not explored the potential of DOD doing their own disposal simply because we were in a mode of getting some contracts in place. I think we are at a point now if we can keep these controls in place, that we will turn our time and attention to DOD capabilities.

(Hasselkus): Another partial answer to that is the "not in my backyard syndrome." We have cases in point right now where there has been a lot of press that we own a lot of chemical stocks needing to be demilitarized. When we go out to public hearings and say, "Okay, we are going to build an incinerator to destroy these materials on the installations where they are," we get ambushed by the politicians and public who say, "We don't want you to burn that here, take it somewhere else!" Then we get ambushed by a whole bunch of other politicians and members of the public who don't want it to be transported across their turf to get it to the other place. Meanwhile, the material is deteriorating and needs to be destroyed. So, you can't leave it where it is, you can't burn it where it is, and you can't take it somewhere else. So we are going back to the public asking, "What do we do?" We are in the process of a public comment period in an environmental document on that. Our preferred alternative is to build incinerators on the installations in question to destroy the stuff in place. Don't know what's going to happen yet. There are a lot of vociferous politicians who say, "We don't like that; we want you to go back and study it some more." I get the feeling that the same thing is going to happen if we try to do that with common industrial materials or conventional military stuff.

(?): If you do go ahead with the demilitarization (demil) plan (which it seems most likely that it appears that it will probably go ahead), wouldn't it be wise to look at constructing those plants to be used at a later date for industrial hazardous waste as well? Would you be specific on that?

(Hasselkus): We haven't summoned those at all. Our conventional demil people will also avoid asking that question. They'll say, "Hey, once that thing is up, can't I then burn my conventional ammunition in it?" And the answer is NO, NO, NO!!! That makes the taxpayer uncomfortable to begin with because you have to spend 42 million dollars to build an incinerator, destroy chemical rounds for 5 or 6 years and then tear it down. In the first place, it sounds like bad use of the taxpayers' money and secondly it sounds like it just isn't true. What's going to happen if we destroy those rounds and continue to bring stuff in and continue to run a destruction facility, and the people in the area around that installation don't want you to bring that stuff in. It creates hazards and the possibility of accidents and so forth. People are scared of that. We're up against that.

(?): There is a major scenario going on, I feel, that's related to conforming storage that we are trying to get in place. I think one of the gentlemen from the EPA talked about worst case. We're trying to get those to the tune of about 100 million dollars across the U.S. and in foreign countries. On two occasions we've had public hearings. An obstacle, if you will, in getting these conforming storage facilities constructed primarily has been the syndrome "not in my back yard." In both cases, the communities involved now are coming back to us saying "if you construct it, can we throw our things in it as well?" So that's rather circular here. How that's going to be resolved, I'm not quite sure.

SESSION IV.
RESEARCH AND DEVELOPMENT

TECHNICAL, ENVIRONMENTAL, AND ECONOMIC EVALUATIONS OF PLASTIC MEDIA BLASTING FOR PAINT STRIPPING

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U. S. Environmental Protection Agency

Abstract

The paper gives the technical, economic, and environmental findings of an evaluation and comparison of three paint removal processes: sandblasting, chemical stripping, and plastic media blasting (PMB). It addresses three areas: the quality of the finished product, the speed of removal, and the environmental impact of each process. Evaluation results indicate that PMB is only marginally more expensive than sandblast paint stripping. However, with only a minor increase in plastic media recycle rates, PMB will be less expensive to operate than sandblasting and has the benefit of lower disposal volumes. The quality of the surface finish using PMB is superior to that using chemicals or sandblasting. PMB does not require masking, or result in surface etching or seal destruction. This permits significant time and long-term cost savings over other techniques. PMB is slower than sandblasting, yet faster than chemical stripping on flat simple surfaces. PMB is faster and more efficient on complex surfaces where hand sanding must be used. PMB can be considered a technically and economically viable alternative paint stripping process for many removal requirements. Although this study was conducted at military maintenance installations, the conclusions should be equally applicable to the private industrial sector.

1. INTRODUCTION

Paint removal operations can be major generators of air, water, and solid waste pollution. There are two traditional methods used for industrial paint removal operations--sandblasting and chemical stripping. Over 60,000 tons per year of methylene chloride is used as a chemical stripping agent resulting in air, water, and solid waste pollution. In addition, countless tons of toxic metal contaminated sand from sandblast stripping must also be disposed of in an environmentally safe manner. Therefore, the unique method of plastic media blasting (PMB) for paint removal promises to significantly reduce air, water, and solid waste pollution from paint stripping operations.

In early 1985, the U.S. Army and the U.S. Environmental Protection Agency embarked upon a joint effort to identify major sources of multimedia pollution from selected Army maintenance operations. An objective was to recommend solutions to the identified pollution problems and evaluate their potential to reduce pollution discharges. The Army facility selected for the initial evaluation program was the Sacramento Army Depot, California. The two major hazardous pollutant sources identified were chemical stripping and sandblasting paint removal operations. Plastic media blasting for paint removal was recommended as a replacement for sandblasting and some chemical stripping operations. A joint research project was initiated with the U.S. Army Toxic and Hazardous Materials Agency to compare PMB with sandblasting and solvent chemical stripping. The sandblasting and the PMB operations were evaluated at the Sacramento Army Depot. The chemical stripping operation was evaluated at the McClellan Air Force Base, California, Air Logistics Center.

This paper presents the technical, economic, and environmental findings of the program that evaluates and compares the three paint removal processes. The paper addresses three areas: the quality of the finished product, the speed of removal, and the environmental impact of each process. More importantly, it shows that, when cost of pollution control is taken into account, the total production cost can be significantly reduced when using PMB.

Background

The use of organic chemicals or sandblasting are the most common methods for removing paint from metal or composite structures. Typical military specification chemical strippers contain up to 85 percent methylene chloride, a designated hazardous pollutant. Other organics which can be found in these strippers include methyl ethyl ketones (MEK) and phenols. These chemicals, when used in industrial stripping operations, result in both air and water

pollution. The increasing restrictions on the discharge of these chemicals and other contaminated wastes by the U.S. EPA and the State environmental agencies will make future discharge and disposal difficult and expensive.

Many institutions have been researching substitute methods for removing old or damaged paint. Methods under investigation include laser light, flash lamps, and high pressure CO₂ pellets--another form of blasting. The methods in most common usage, however, are chemical stripping and sandblasting. Both of these methods, however, have inherent problems. Sandblasting can be aggressive to softer metals and composites. Chemicals result in large volumes of contaminated rinse water and toxic sludges.

PMB is a unique variation of the sandblasting process which uses plastic beads rather than silica sand. Similar to sandblasting, the media impacts upon the surface and attacks the paint covering the substrate. However, due to the hardness of the plastic beads, approximately 3 to 5 Mohs, it is non-abrasive to the metal substrate, which typically has surface hardness greater than 6 Mohs. Sand has a Mohs hardness of approximately 7. The relatively low Mohs hardness of the plastic beads permits PMB to be used on surfaces and in areas which cannot be processed by sandblasting or chemicals and, therefore, has a significant advantage over other stripping techniques. A disadvantage, however, is that PMB will not remove rust, since the beads are softer than rust.

Objective

The objective of this study was to show that PMB is significantly cheaper in total manufacturing costs when compared to other paint stripping processes. When the real costs associated with pollution control are taken into account, the resulting costs can be significantly greater than when defining process costs by only material, equipment, and labor costs. PMB has the advantage of lower pollution, thus lower resulting environmental control cost impact. This study evaluated those costs.

Approach

The subjects of the evaluations were military shelters of the type used to house communication electronics. The PMB evaluation program was designed to compare stripping processes in three areas: the quality of the surface finish, the speed of paint removal, and the environmental impact of the process and the ultimate processing cost when taking environmental control into account. The quality requirements of the surface finish were defined by military specifications, with surface quality evaluations completed by facility technicians. The stripping speed and environmental impact evaluations were completed by using elapsed time and analytical results, respectively. The time determinations were nozzle-on elapsed times for PMB and sandblasting evaluations, and application, setting, and rinsing elapsed times for chemical stripping. The recorded elapsed times did not include unit preparation times

for sandblasting and chemical stripping, although they would have further increased unit processing times for the two processes. Also, due to the aggressive nature of sandblasting and chemicals, hand sanding is normally required to process the interior of the electronic shelters during these stripping operations. PMB can be used on the interior surfaces without causing damage. Hence, hand sanding was accounted for during the sandblasting and chemical stripping evaluations.

A total of 14 shelters of similar size and configuration were evaluated. They included three evaluated for chemical stripping, six for sandblasting, and five for PMB. Figure 1 shows a typical electronic shelter of the type used during the evaluation. The quantitative data collected during each evaluation run included total shelter surface area, stripping time, paint type, material used, and volume of waste generated.

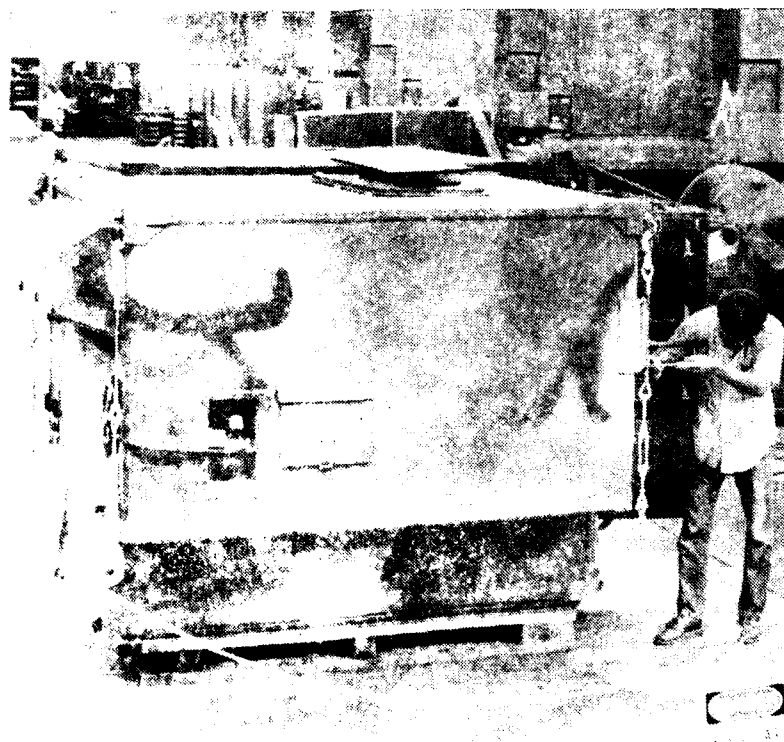


Figure 1. Typical military electronics shelter.

2. PROCEDURE

Sandblasting

Sandblasting evaluations were conducted at the Sacramento Army Depot, California. A total of six shelter stripping operations were observed. Due to the abrasive effect of sand on the aluminum surface of the shelters and potential contamination of electronics by sand, only the outside of the shelters was sandblasted. All sandblasting was conducted in dedicated enclosure. The inside of the shelters was sanded by hand. As shown in Table 1, the paint removal rates for sandblasting on the outside of each shelter ranged between 2.86 and 10.49 ft²/min.* However, the inside removal rate averaged only 0.74 ft²/min. Thus, the actual cleaning rate for sandblasted shelters for both inside and outside ranged between 1.8 and 5.6 ft²/min. It should also be noted that inside stripping was incomplete and of minimal quality. As expected, multilayered coatings required the greatest effort. As shown for units 3 and 5 in Table 1, which were coated with multilayered camouflage paints, the paint removal effort was two to three times slower than for single coatings.

Chemical Stripping

Chemical stripping evaluations were conducted at the McClellan Air Force Base, California, Air Logistics Center. One small and two medium size shelters were observed. Data similar to those taken during the sandblasting evaluations were collected. However, the total outside processing time included the sum of the chemical application, reaction, and rinse-down elapsed times. The stripper was primarily methylene chloride in a wax base to allow adherence to the unit surface. For certain difficult removal situations a supplementary phenolic stripper was used. Table 2 summarizes the results of the chemical stripping evaluations.

Chemical stripping was also determined to be a time-consuming process with equally large volumes of liquid waste. Due to the corrosive nature of the stripping chemical, only the outside was chemically stripped. The inside of each unit was sanded by hand which, when combined with the outside stripping time, was less than the sandblasting rate. The waste generated as shown in Table 2 was approximately equivalent to that generated during sandblasting ranging between 1.7 and 3.3 gal. of liquid waste per ft² of surface area. The waste volumes were determined by the thickness of the coating and its resistance to the chemical stripper. As shown for unit 3 in Table 2, the stripping rate was significantly less than for the larger units. Due to the additional stripper applications, the waste generation rate was significantly greater. Approximately 25 percent of the liquid waste generated required handling and disposal as a hazardous waste sludge.

*Readers more familiar with metric units may use the conversion table at the end of this paper.

TABLE 1. SUMMARY OF SANDBLAST STRIPPING

Unit No.	Area Stripped (ft ²)		Stripping Time (min)		Rate (ft ² /min)		Estimated Stripping Rate (ft ² /min)	Sand Used (lb)	Material Rate (lb/ft ²)	Waste Rate (lb/ft ²)
	Outside	Inside	Outside	Inside	Outside	Inside				
1	189	71 ^a	24.4	93 ^a	7.74	0.76 ^a	4.25	325.6	1.7	1.7
2	189	36 ^a	25.0	50 ^a	7.56	0.72 ^a	4.14	333.3	1.8	1.8
3	189 ^c	--	66	--	2.86	0.74 ^b	1.8	880.0	4.7	4.7
4	249	--	33	--	7.54	0.74 ^b	4.14	440.0	1.8	1.8
5	249 ^c	--	67.3	--	3.70	0.74 ^b	2.20	897.3	3.6	3.6
6	249	--	23.8	--	10.49	0.74 ^b	5.60	317.6	1.3	1.3

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^aReal time data ^bEstimated sand rate ^cMultilayered

TABLE 2. SUMMARY OF CHEMICAL STRIPPING

Unit No.	Area Stripped (ft ²)		Stripping Time (min)		Rate (ft ² /min)		Total Average (ft ² /min)	Chemical (lb) Stripper ^a	Chemical Used (gal.) Water	Chemical Use Rate (lb/ft ²)	Waste Rate (gal./ft ²)
	Outside	Inside	Outside	Inside	Outside	Inside					
1	342	N/A	692	N/A	0.50	0.74 ^b	0.62	194	1572	0.57	1.9
2	387	N/A	1345	N/A	0.30	0.74 ^b	0.51	370	2636	0.96	1.7
3	180 ^c	N/A	1126	N/A	0.17	0.74 ^b	0.46	149	2336	0.83	3.3

^aIncludes all organics^bEstimated from sandblast results^cSupplementary phenolic stripper used

Plastic Media Blasting

Five shelters were processed at the Sacramento Army Depot using PMB. The units were of similar size and configuration of those evaluated for chemical stripping and sandblasting. However, unlike the chemical stripping and sandblasting operations, both the outside and inside of each shelter was stripped using PMB, thus eliminating the time-consuming hand sanding. The times determined for stripping those units, therefore, included both the inside and outside. In addition, since PMB had no effect on seals, gaskets, or surface preparation, masking was not required.

The plastic media was blasted at approximately 30 psi, which is lower than for sandblasting. Over the total evaluation program, a total of 450 lb of paint dust and media were discarded as waste. This represented 18 percent of the media charge. Table 3 summarizes the results of the PMB evaluation. Since hand sanding was not required, the inside cleaning rate was typically no greater than twice the outside cleaning rate. This difference can be attributed primarily to the limitations of the evaluation site. Unlike a dedicated PMB installation with bead retrieval apparatus and filters, the inside of each shelter was stripped without the aid of bead retrieval or ventilation to remove dust. Thus, periodic shutdowns were required during the evaluation to permit bead retrieval and dust settling. The stripping rate for shelter A (Table 3) was significantly less than those recorded for the remaining shelters in the series. A silica impregnated floor coating was used which required significantly greater effort to strip. The stripping rate for the remaining shelters reflected the relative paint thicknesses between the single coatings and the multilayered camouflage coatings.

TABLE 3. SUMMARY OF PMB PAINT REMOVAL

Shelter	Area (ft ²)			Stripping Time (min)		Cleaning Rate (ft ² /min)		Plastic Media Usage Rate (lb/ft ²)	Waste Material (lb)	Material Waste (lb/ft ²)
	In	Out	Total	In	Out	In	Out			
A ^b	394	335	729	548	201	789	0.67	1.67	0.92	<0.18
B	178	168	346	82	139	221	2.17	1.21	1.57	<0.18
C	178	168	346	102	69	171	1.75	2.43	2.02	<0.18
D ^b	394	335	729	136	123	259	2.90	2.72	2.80	<0.18
E ^b	178	168	346	47	113	160	3.79	1.49	3.06	<0.18

^aEstimated from total waste product generated over the evaluation program

^bMultilayered camouflage enamel paint

3. RESULTS AND DISCUSSION

The viability for industrial application of any paint stripping process is defined by its costs and the quality of the surface finish after stripping. Thus, the objective of this program was to determine the technical and economic factors that define the limits of the PMB technique and compare them to those for sandblasting and chemical stripping. The results relied both upon the subjective judgements of quality control experts and on realtime data collected during stripping operations at two military maintenance facilities.

The surface quality after paint stripping was determined by quality control inspection based upon military specification surface requirements. The three techniques produced acceptable repainting surfaces, although of varying degrees of quality. The inside surfaces of the sandblasted and chemically stripped units were of minimum overall quality since hand sanding permits only partial removal of paint. The PMB units were determined to have the best overall surface quality. For PMB the surface quality of the inside was considered equivalent to the outside surfaces. The stripping rate of PMB on simple flat metal (T2024 aluminum) surfaces was determined to be less than that for sandblasting, but greater than for chemical stripping. However, due to the complex surfaces inside the shelters, PMB was significantly faster (by a factor of three) on the interior surfaces when compared to hand sanding. Thus, based on the average stripping rate for each process, PMB was at least 30 percent faster than sandblasting and 65 percent faster than chemical stripping, since both the latter processes require hand sanding of the interior surfaces.

Because sandblasting waste is not presently disposed of as a hazardous waste at the test site, PMB was determined to be marginally more expensive than sandblasting, but significantly less expensive than chemical stripping. As shown in Table 4, and based on an 82 percent recycle rate for PMB, the process cost for sandblasting was determined to be approximately \$0.35 per ft², with PMB and chemical stripping \$0.47 and \$2.58 per ft², respectively. By breaking down the respective cost element as in Table 4, it can be seen that the significant cost element for sandblasting, however, was labor at \$0.25 per ft². The materials costs were \$0.09 per ft² for high-grade sand, and subsequent waste disposal was less than \$0.01 per ft² stripped. The disposal rate for PMB was determined to be marginally higher than sandblasting due only to the designation of the subject sandblast waste as non-hazardous. A change in the designation of sandblast waste would result in a waste disposal cost for sandblast in excess of \$0.13 per ft² and thus increase the total process cost for sandblasting to \$0.50/ft². Due to the efficiency of PMB in processing the inside of the shelters, thus eliminating time-consuming hand sanding, the actual labor rate for PMB was significantly lower than for the other processes.

TABLE 4. COMPARISON OF PAINT STRIPPING METHODS
FROM DATA COLLECTED DURING EVALUATION

Paint Stripping Method	Average Stripping Rate (ft ² /min)		Material Use Rate (lb/ft ²)	Waste Generation Rate (lb/ft ²)	Estimated Labor Rate ^a (\$/ft ²)	Material Cost Rate (\$/ft ²)	Waste Disposal Rate (\$/ft ²)	Total Process Cost ^b (\$/ft ²)	Projected Process Cost ^c (\$/ft ²)
	Outside	Inside							
Sandblasting	6.64	0.74	2.4	2.4	0.25	<0.09	<0.01 ^d	0.35	0.50
Chemical	0.32	0.74	0.8	2.3	0.65	1.80	0.13 ^e	2.58	2.58
Plastic Media Blasting	2.26	1.9	<0.18	<0.18	0.10	0.36	0.01	0.47	0.31

^aLabor rate estimated at \$10.00 per hour

^bBased on collected data

^cBased on added assumptions: (1) Sandblast waste treated as hazardous waste
(2) 90 percent bead recycle rate

^dDisposed of at nonhazardous rate

^eApproximately 25 percent of total liquid waste disposed of as hazardous waste

Finally, the plastic media recycle rate as determined during this program was 82 percent. This was due primarily to the limitation of the experiment. Since the beads can be efficiently classified and recycled at greater than 90 percent, it is therefore possible and probable that most operations would operate at a 90 to 95 percent recycle rate. Thus, the major cost item for PMB material cost at \$0.36 per ft², could be significantly lowered. At a 90 percent recycle rate, the material rate for PMB would be reduced by 55 percent to approximately \$0.20 lb/ft² and thus become more economical than sandblasting or chemical stripping. The last column of Table 4 compares the process costs based on a 90 percent plastic media recycle rate.

Conclusions

The results of the evaluation program data for PMB indicate that PMB is only marginally more expensive than sandblast paint stripping. However, with only a minor increase in plastic media recycle rates, PMB will be less expensive to operate than sandblasting and has the benefit of lower disposal volumes.

The quality of the surface finish using PMB is superior to that using chemicals or sandblasting. PMB does not require masking, or result in surface etching or seal destruction. This permits significant time and long-term cost savings over other techniques.

PMB is slower than sandblasting, yet faster than chemical stripping on flat simple surfaces. PMB is faster and more efficient on complex surfaces where hand sanding must be used. PMB can be considered a technically and economically viable alternative paint stripping process for many paint removal requirements. Although this study was conducted at a military maintenance installation, the conclusions derived should be consistent in the private industrial sector.

TABLE 5. METRIC CONVERSION TABLE

<u>Nonmetric</u>	<u>Times</u>	<u>Yields Metric</u>
ft ²	0.09	m ²
gal.	3.79	L
lb	0.454	kg
psi	6.89	kPa
ton	907.18	kg

TREATMENT OF THE PLASTIC BEAD BLASTING RESIDUE RESULTING FROM PAINT STRIPPING OF F-4 AIRCRAFT

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ABSTRACT

This paper presents the research being conducted on treatment of bead blasting waste residue by the Air Force Engineering and Services Center (AFESC) Environics Division.

Background information is given on plastic bead blasting of aircraft as an alternative to chemical stripping. The advantages of bead blasting versus chemical stripping are outlined. One clear advantage is the elimination of large quantities of liquid hazardous wastes which are generated during chemical stripping. The bead residue from plastic bead stripping of aircraft is a solid waste. However, the waste bead residue is a hazardous waste since the EP toxicity limit for chromium is consistently exceeded.

Of the 1500 pounds of waste residue produced per F-4 aircraft, approximately five percent or less is due to paint. Preliminary sampling analysis shows that over 80 percent of the removable chromium is located in the 100 mesh-size fraction and smaller. This size fraction represents more than 50 percent of the total waste volume. Separation of this size fraction from the remaining volume would possibly result in a 50 percent reduction in the hazardous waste volume.

Results of laboratory separation techniques for removing the metal from the bead residue are discussed. Further tests will involve additional analysis of the waste bead residue and field testing of cyclone separation. Various types of blasting wastes will be evaluated for similar treatment. Fire potential of the bead blasting operation at Hill AFB will also be evaluated.

Introduction

Plastic bead blasting presents an alternative to chemical stripping of aircraft. The problems associated with chemicals and liquid chemical wastes are eliminated. However, the 1500 pounds of wastes produced from bead blasting an F-4 aircraft are hazardous mainly due to chromium content. Air Force Engineering and Services Center (AFESC) Environics research is being conducted to try to treat this waste. The ultimate goal is to treat the waste so that the entire waste volume, or most of the waste volume, can be disposed of as a non-hazardous waste. If successful, further savings in disposal costs can be obtained.

Background

Figure 1 shows the plastic bead blasting facility at Hill AFB. This structure was specifically designed for bead blasting of smaller aircraft. Currently, F-4 aircraft are being stripped with plastic beads in this facility.

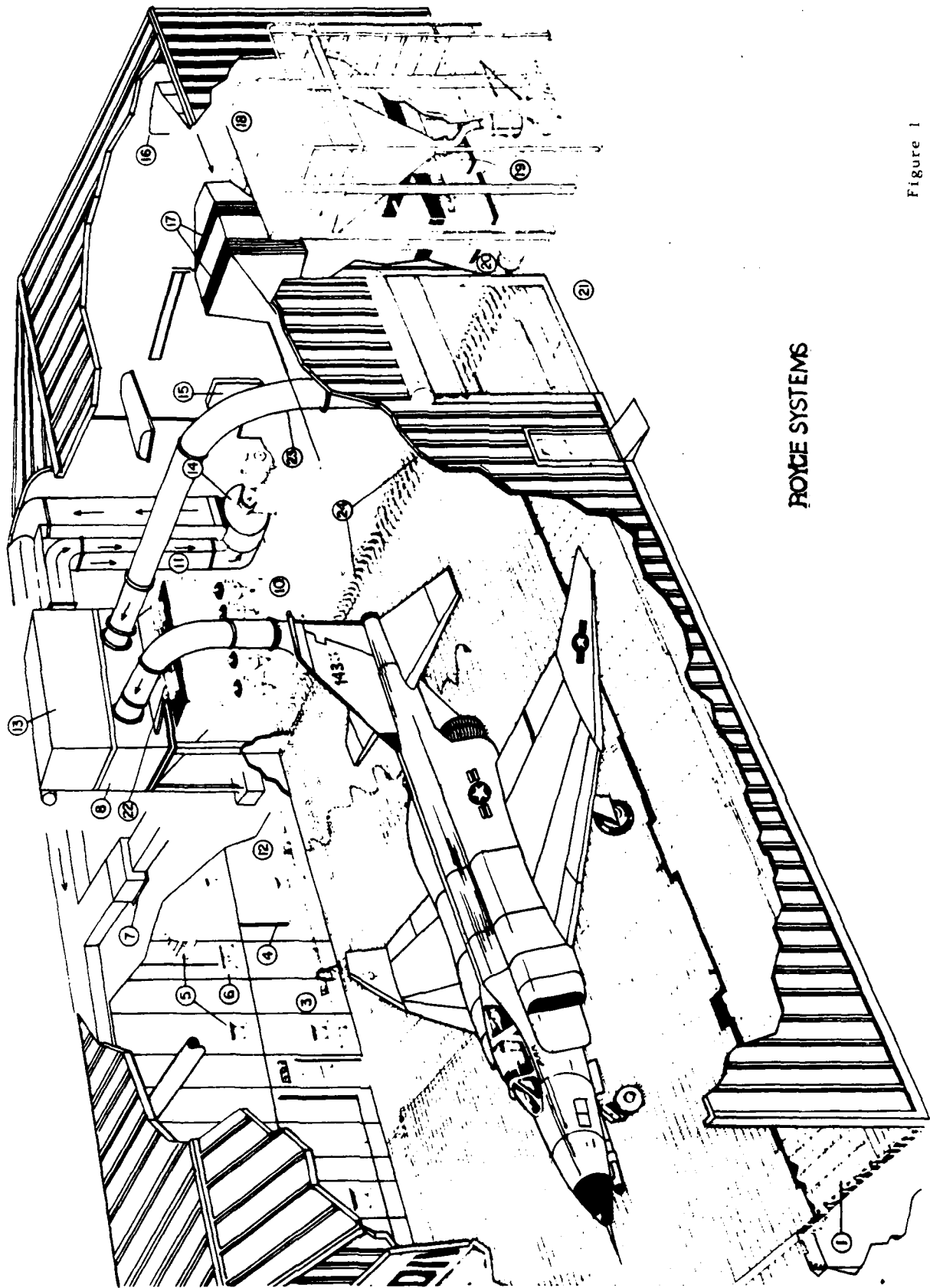
The floor of this structure allows the beads and paint particles to pass on through. Beads are recirculated through the blasting system. Particles larger than 60 mesh are sent back through for repeated blasting. Particles smaller than 60 mesh are too small for effectively stripping the paint. These particles are removed from the blasting recirculation system and become a waste. The waste is hazardous due to metal content.

The bead blasted aircraft provides a smooth surface suitable for painting.

The conventional method for depainting of aircraft is by chemical stripping. Chemical stripping of aircraft is messy and hazardous. For example, phenols in strippers present significant environmental concerns. Phenols can disrupt treatment at industrial waste treatment plants (IWTP). Methylene chloride in strippers are potentially carcinogenic and present a health hazard to the worker. Steps required to protect the worker may include personal protection and periodic medical exams. There is also a concern with the floor during the chemical stripping process. The floor can become slippery and dangerous to the worker. The chemicals can also damage the surface of the floor.

Tens of thousands of gallons of water become contaminated from chemical stripping of F-4 aircraft. Treatment of the chemicals at the IWTP results in as much as 9500 pounds of sludge per F-4 aircraft. This compares to about 1500 pounds of bead blasting residue from plastic bead blasting. Chemical stripping may also result in several barrels of stripping solution and paint residue. Also, hazardous waste management is more of a problem for liquids than for solids.

There are several advantages of plastic bead blasting versus chemical stripping aircraft. It takes 10 times longer to strip an aircraft using chemicals versus using plastic bead blasting. The time reduction and ease of operation reduces manpower requirements. This provides significant monetary savings. These manhours and cost savings can be directed to other mission



ROYCE SYSTEMS

Figure 1

essential areas. As already mentioned, the environmental and health problems associated with chemical strippers are eliminated. Again, the disposal of the bead residue is not as difficult as treating and disposing of wastes associated with chemical stripping.

Table 1 shows the results of EP toxicity tests for various samples. The EP toxicity limit for chromium is 5 mg/L, as shown in the column to the right. The EP toxicity limit for cadmium is 1 mg/L. The waste is hazardous if these values are exceeded. As demonstrated by the five samples in Table 1, the EP toxicity for chromium is consistently exceeded. The limit for cadmium is only occasionally exceeded. These five samples were from blasting wastes of different aircraft. The waste residue can contain lead, but the EP toxicity limit for lead will not be exceeded under normal conditions.

Objectives

Our research objectives were as follows:

- (1) Develop and evaluate a treatment method so that the entire waste volume, or most of the waste volume, can be disposed of as a non-hazardous waste.
- (2) If treatment is not possible, incineration could be considered as a disposal alternative.

Incineration of bead blasting wastes will be evaluated by Hill AFB. Although incineration may end up as the best solution, we do not see it as a near-term solution. At best, incineration of plastic bead wastes is probably five years away.

Evaluation of Techniques

Up until now, the research program has involved:

- (1) Characterization of the bead blasting waste.
- (2) Evaluation of potential techniques for removing the chromium and cadmium from the waste residue.

Techniques evaluated have included chemical treatment methods. Chemical methods were not successful. For example, a chemical washing procedure was attempted. After chemical washing, EP toxicity tests were conducted. It was found that chemical washing resulted in lead concentrations exceeding EP toxicity limits. Prior to chemical washing, lead did not present any problems as shown by EP toxicity tests.

Physical separation methods present a possible solution; however, screening out the fraction of waste containing the metals was found to be a difficult and slow process. Cyclone separation does present a possible solution. Cyclone separation could possibly be used concurrently during the blasting process. Treatment of the waste separate from the actual blasting

process is not desired. This would add an extra step and would require treatment of a hazardous waste. Hazardous waste treatment requires special permitting.

Encapsultaion was also evaluated. Encapsulation of the metals successfully tied up the cadmium and chromium, but was found to be too expensive to use as a treatment alternative.

As previously mentioned, incineration as a disposal alternative will be evaluated at Hill AFB.

The waste residue was screened in the laboratory using standard sieves. The waste was separated into various size fractions. EP toxicity tests were done on the full sample and on the various size fractions (Table 2). Again, the waste particle sizes are 60 mesh and smaller. Results of EP toxicity tests on various size fractions have shown the cadmium and chromium is concentrated in the size fraction smaller than 100 mesh. The 100 mesh and smaller is 50 percent of the entire waste volume. Removing the fraction containing the metals would effectively reduce the hazardous waste volume by 50 to 75 percent. One way to separate the 100 mesh and smaller size would be by using a cyclone or classifier. A sharp separation would not be required for sufficient removal of the chromium and cadmium. Recent tests have shown that approximately 80 percent of the removable chromium is located in the size fraction smaller than 100 mesh.

TABLE 1
EP Toxicity Test Results (ppm)

	SAMPLE 1	SAMPLE 2	SAMPLE 3	SAMPLE 4	SAMPLE 5	EP LIMIT
Chromium	12.2	39	25	12.5	21	5.0
Cadmium	0.19	1.6	0.17	0.2	1.1	1.0

Table 2
EP Toxicity Tests of Different Size Fractions (mg/L)

<u>Elements</u>	<u>Full Sample</u>	<u>-100 Mesh</u>	<u>+50 Mesh</u>	<u>Limit</u>
Chromium	13.00	19.0	0.80	5
Cadmium	0.32	1.0	0.19	1

Expanded Project

The waste residue from bead blasting of F-4 aircraft at Hill AFB represents only part of the total blasting waste. As shown in Table 3, the waste from plastic bead stripping of F-4 aircraft represents 25 percent of the total blasting waste. The waste from plastic bead stripping of wing folds represents 15 percent of the total. Plastic media combined with other blasting materials represents 25 percent. Garnet blasting waste represents 30 percent. The blasting wastes in Table 3 are generally hazardous due to metal content. In the expanded project, we will also evaluate treatment of these other types of wastes.

Summary

In summary, there are several advantages of plastic bead blasting versus chemical stripping. The bead residue from plastic bead stripping of F-4s is a hazardous waste. This is due mainly to EP toxicity values for chromium. Research is being done on treatment and disposal of the bead blasting residue. Reducing the hazardous waste volume would result in further savings in disposal costs.

Finally, how well does plastic bead blasting compare to chemical stripping as far as the amount of wastes produced? Consider the amount of sludge created at the IWTP from treatment of chemical strippers. Compare this to the weight of bead blasting wastes. Presently, one aircraft chemically stripped produces as much hazardous waste by weight as 6.5 aircraft which are stripped with plastic beads. If the plastic bead hazardous waste volume is reduced 50 percent, one aircraft chemically stripped would produce as much hazardous waste by weight as 13 aircraft stripped with plastic beads. With disposal costs of \$100 to \$300 per ton, significant savings in disposal costs can be realized.

Table 3

Blasting Residue from Hill AFB (Through March 86)

<u>Material</u>	<u>Amount</u>	<u>Percent of Total</u>
Plastic Bead (F-4)	43,000	25
Plastic Bead (Wing Fold)	26,000	15
Plastic and Other	43,400	25
Garnet	52,000	30
Others	7,400	5

THE INVESTIGATION OF ALTERNATE PAINT STRIPPERS TO REDUCE TOTAL TOXIC ORGANICS (TTOs) IN METAL FINISHING WASTEWATER

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ABSTRACT

Army depots must frequently remove paint as part of routine operations. Stripper chemicals enter metal finishing wastewater through dragout and rinsing procedures. The most common major component in cold paint strippers is methylene chloride, a suspected carcinogen which is not biodegradable. Methylene chloride is included in the list of materials to be monitored and reported as part of a facility's TTO included in their discharge permit. There are several strategies for reducing methylene chloride in discharge streams, but the least expensive and simplest is to find a substitute stripper that is more environmentally acceptable. A joint Army/EPA contract study has tested ten paint strippers which were either reduced or free of methylene chloride on various military paint samples. This paper presents the results of this testing program.

THE INVESTIGATION OF ALTERNATE PAINT STRIPPERS TO REDUCE TOTAL TOXIC ORGANICS (TTO's) IN METAL FINISHING WASTEWATER

In September 1984, the USEPA enacted discharge criteria for wastewater from metal finishing facilities which set a maximum concentration of TTO at 2.13 mg/l. To enable Army depots to meet this limit, a joint Army/EPA research study assessed several military metal finishing facilities and made recommendations for process and procedural changes to reduce the discharge of specific organic compounds of concern.

A significant contributor to the total toxic organics is methylene chloride, the active component in chemical paint stripper formulations which are employed as part of metal-part refinishing operations. While some paint stripping operations can be done with alternative techniques such as Plastic Media Blasting, the use of chemical strippers for cleaning large quantities of small, irregularly shaped parts will remain the most efficient method of operation. Therefore a search was made for alternate paint stripping formulations that perform effectively while being reduced or void of methylene chloride and other TTO compounds. Use of alternatives should enable the depot facilities to achieve compliance with the TTO discharge limit.

The Army maintains its field equipment by periodic maintenance which includes rebuilding, testing, and refinishing. Several types of very durable paints are used to protect the equipment from harsh conditions of the battlefield, the environment, and more general storage conditions, transport, and use.

Under a contract with Carltech Associates, a paint-stripping performance study was conducted on painted metal coupons prepared from panels supplied by Sacramento Army Depot personnel. Eight combinations of metal substrate, primer and topcoat representing those frequently encountered on military equipment were employed (listed on Table 1).

A frequently used commercial paint stripping formulation is MS-111 which is 85% methylene chloride, 10% phenol, and 5% formic acid; this was the standard stripper to which other formulations were compared. A telephone and mail survey yielded eight promising candidate strippers for the testing program. Four of these were completely free of methylene chloride, and the remaining four had less methylene chloride than the MS-111. One formulation was tested at 180 degrees F as well as at ambient temperature, and another was tested at both full strength and at a one to one dilution with water. This made 10 test formulations plus the MS-111 control or standard.

Tables 2 and 2A identify the formulations that were evaluated.

PROCEDURE

Each test stripper formulation was exposed to two coupons from each of the 8 test panels. One coupon was submersed for twenty minutes, to simulate depot procedures, and the other coupon was submersed for 35 minutes. Coupons were then rinsed, dipped in caustic, steam cleaned, and dried. Coupons were weighed and their thickness measured both before and after stripping. Visual and 7X

magnification photos were used to evaluate the percentage of topcoat and primer removed.

RESULTS

The estimation of percentage removal was the most reliable measure of effectiveness that was evaluated for these trials. The coupon weights and thickness values generally correlated with these results.

The results on the enamel and epoxy coatings are summarized in Table 3 for the methylene chloride based strippers and in Table 4 for the non-methylene chloride based strippers. The gray enamels were removed readily by all the formulations; the white enamel was partially resistant to some formulations; and the epoxy topcoat was removed best by the methylene chloride formulations.

Stripping the polyamides was difficult; non-methylene chloride strippers could not lift them from the substrate at room temperature. The neutral methylene chloride formulations were ineffective (as shown in Table 5). The non-methylene chloride stripper, ALM that was tested at 180 degrees F was as effective as those with acid and methylene chloride (Table 6).

The two strippers that performed comparably with MS-111 contained reduced quantities of methylene chloride: S-28 and Quick Strip No. 8. These were also tested against aged coatings, which are harder to remove, and they performed equally well as MS-111.

CONCLUSIONS AND RECOMMENDATIONS

1. Of the formulations, only strippers containing methylene chloride, phenol, and acid could remove paint from all 8 types of samples tested in 20 minutes or less.
2. A water-miscible methylene chloride stripper can be diluted and remain effective; limits of dilution should be determined.
3. Facilities that strip only enamels have several non-methylene chloride alternatives which could be used to eliminate TTO's from this operation.
4. Facilities that could heat the stripper tank could use ALM to remove enamels and even the tougher polyamides while eliminating TTO's from the stripping operation.
5. Epoxy paints require methylene chloride strippers with a formic acid activator. However the diluted formulations are suitable and the limits of dilution should be determined.
6. The solvent n-methyl-2-pyrrolidone is an effective, non-toxic stripper for removing paint from aluminum. While not yet available in commercial formulations, further investigation is warranted.
7. A single broad-application alternative to MS-111 that is non-polluting was not discovered. However alternatives capable of reducing methylene chloride in wastewater from paint stripping operations have been identified.

TABLE 1 TEST PANELS

Code	Color	Material	Primer	Topcoat
A	lt. gray	Aluminum	Zinc	Enamel
B	dk. gray	Aluminum	Zinc Chromate	Enamel
C	white	Aluminum	Zinc Chromate	Enamel
D	cream	Aluminum	Primer	Epoxy
E	black	Aluminum	Epoxy	Polyamide
F	black	Aluminum	Water Reducible	Polyamide
G	black	Aluminum	Zinc Chromate	Polyamide
H	black	Steel	Epoxy	Polyamide

TABLE 2 -- STRIPPING FORMULATIONS TESTED

Code	Trade Name	Supplier	Composition
I	84TB-227	Nalco Chemical	Cyclic Amide
II	M-Pryol	GAF	N-Methyl-2-pyrrolidone
III	S-26	Enthone	Methylene chloride 50%; Phenol 20%; Formic acid 15%
IV	Stripeeze	Savogran	Methylene chloride <20%; Toluene <40%; Methanol <30%; Acetone <25%
V	Kutzit	Savogran	Methylene chloride <30%; Toluene <30%; Methanol <30%; Acetone <30%
VI	Quick Strip No. 8	Mitchell- Bradford	Methylene chloride 60%; An acid

TABLE 2A — STRIPPING FORMULATIONS TESTED

Code	Trade Name	Supplier	Composition
VII	MS-111	Miller-Stephenson	Methylene chloride 85%; Phenol 10%; Formic acid 5%
VIII	ALM	Oakite	Monoethanolamine 10%; Furfuryl alcohol <10%; Tributyl phosphate <5%; Sodium hydroxide <1%
IX	FHS	Oakite	Butyl cellosolve 35%; Formic acid 15%; Mixed aromatic hydrocarbons 10%; Diisobutyl ketone 10%; Dodecylbenzene sulfonic acid; Hydrofluoric acid <5%
X	ALM	Oakite	Same as VIII except at 180 degrees F
XI	S-26	Enthone	Same as III, but diluted 1:1 with water

TABLE 3 — RESULTS

METHYLENE CHLORIDE BASED STRIPPERS ON ENAMEL & EPOXY
ON ALUMINUM PANELS — Percentage Removal

Code	Trade Name (Primers)	Lt. gray Enamel Zinc	Dk. gray Enamel Zinc Chromate	White Enamel	Cream Epoxy Primer
III	S-26	100/100	100/100	100/100	100/100
IV	Stripeeze	100/100	100/100	75/85	0/0
V	Kutzit	100/100	100/100	50/70	0/0
VI	Quick Strip No. 8	100/100	100/100	99/99	3/100
VII	MS-111	100/100	100/100	100/100	100/100
XI	S-26 (1:1)	100/100	100/100	100/100	100/100

20 minute submersion/35 minute submersion results

TABLE 4 -- RESULTS

NON-METHYLENE CHLORIDE BASED STRIPPERS ON ENAMEL & EPOXY
ON ALUMINUM PANELS --Percentage Removal

Code	Trade Name (Primers)	Lt. gray Enamel Zinc	Dk. gray Enamel (Zinc Chromate)	White Enamel	Cream Epoxy Primer
I	84TB-227	100/100	100/100	20/95	0/0
II	M-Pryol	100/100	100/100	50/90	0/55
VIII	ALM	100/100	100/100	25/25	0/0
IX	FHS	100/100	100/100	100/100	0/0
X	ALM 180 deg. F	100/100	100/100	100/100	0/0
20 minute submersion/35 minute submersion results					

TABLE 5 -- RESULTS

METHYLENE CHLORIDE BASED STRIPPERS ON BLACK POLYAMIDES
ON ALUMINUM AND STEEL PANELS -- Percentage Removal

Code	Trade Name (Primers)	Aluminum Epoxy	Aluminum Water- Reducible	Aluminum Zinc Chromate	Steel Epoxy
III	S-26	100/100	100/100	100/100	100/100
IV	Stripeeze	0/0	0/0	0/0	0/0
V	Kutzit	0/0	0/0	0/0	0/0
VI	Quick Strip No. 8	100/100	100/100	100/100	100/100
VII	MS-111	100/100	100/100	100/100	100/100
XI	S-26 (1:1)	100/100	100/100	100/100	100/100
20 minute submersion/35 minute submersion results					

TABLE 6 -- RESULTS
 NON-METHYLENE CHLORIDE BASED STRIPPERS ON BLACK POLYAMIDES
 ON ALUMINUM AND STEEL PANELS -- Percentage Removal

Code	Trade Name (Primers)	Aluminum Epoxy	Aluminum Water- Reducible	Aluminum Zinc Chromate	Steel Epoxy
I	84TB-227	0/0	0/0	0/0	0/0
II	M-Pryol	0/0	0/0	0/0	0/0
VIII	ALM	0/0	0/0	0/0	0/0
IX	FHS	50/50	95/50	20/10	0/100
X	ALM 180 deg. F	100/100	100/100	100/100	100/100
20 minute submission/35 minute submission results					

PAINTING MATERIALS AND OPERATIONS AT NAVY SHORE ACTIVITIES AFFECTED BY ENVIRONMENTAL CONSIDERATIONS

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Research and development are continuing in an effort to introduce simpler and more economical procedures for protecting both our vital shore facilities and our environment. This report presents information on such research and development at the Naval Civil Engineering Laboratory (NCEL) and at some other Navy organizations. It also describes some new changes that have already been implemented into the system.

Sandblasting is still the preferred method of surface preparation for painting, despite the generation of particulate materials that enters the surrounding air. The use of silica sand and slag materials containing significant amounts of heavy metals are not recommended. Alternate abrasives such as plastics clean steel fairly well but the effect of the surface profile produced has not been determined. High energy (e.g., xenon arc) cleaning is costly in terms of both labor and energy. Waterblasting and wet sandblasting are used effectively on a variety of substrates to keep down the particulate dust. The effects of corrosion inhibitors, added to the water to prevent flash rusting, on coating performance has not been fully established. The use of a petrolatum paste over wirebrushed steel has been effective, but the performance of over-rust paints has generally been poor.

NCEL is conducting investigations into environmentally acceptable levels of organic solvent, lead and chromium-free primers, and EPA-approved mildewcides. Water-borne coatings have been found to perform as well on wood as have alkyd coatings; this has not been the case to date on steel. An investigation for a lead and chromium-free replacement for MIL-P-23377 is continuing. In a field test of all available mildewcides approved by the Environmental Protection Agency (EPA) in alkyd and latex paints on wooden panels, only one was resisting mildew growth at an acceptable level after one year.

1 INTRODUCTION

Background

Naval shore activities are attempting to protect vital shore facilities in the most economical manner. Various restrictions have relatively recently been made on the type of blasting abrasives and the dust plume resulting from blasting. Most areas in the state of California now have restrictions on the amount of volatile organic compounds (VOC) in paints. Restrictions have also been made on the use of lead compounds in paints. Chromium compounds in paint have been reported to be hazardous. EPA has restricted the use of mildewcides in paint.

Objective

The objectives of this report are (1) to discuss the research and development being done at NCEL to permit naval shore activities to provide protection to shore facilities while conforming to environmental restrictions and (2) to describe what changes have already been implemented.

Approach

NCEL has been directed by the Naval Facilities Engineering Command (NAVFAC) to conduct several investigations related to environmental aspects of painting. Each of these will be described separately. As each subject is discussed, other pertinent information will be presented, in order to provide a bigger picture of the problem and attempts at resolving it.

2 PRESENTATION OF TECHNICAL INFORMATION

Surface Preparation

Abrasive blasting is still the preferred method of surface preparation of steel, because it provides the cleanliness and profile required for good coating performance. Its continued use, however, is in jeopardy because of environmental limitations.

NCEL has reported (Ref. 1) that certain generic types of coatings require specific abrasives for optimum performance. The use of silica abrasives has recently been restricted, because it has been reported to cause silicosis. Other restrictions have been placed on abrasives that cause excessive particulate dusting. Indeed, there are restrictions in most areas of California on the opacity of blasting plumes. The Naval Sea Systems Command (NAVSEA) has also restricted the amount of heavy metals permitted in abrasive slags. NCEL has examined a few plastic abrasives and found them to provide the same degree of adhesion of MIL-P-24441 (the Navy's most widely used epoxy) as does abrasive blasting.

NCEL has also used a xenon arc as an alternative to abrasive blasting of steel surfaces for coating. Most generic types of paint performed about as well over this surface as they did over a near white abrasive blast (SSPC SP-10).

High pressure waterblasting has been effectively used by many Navy shore activities to prepare wood, concrete/masonry, and steel surfaces for painting. Low pressures and detergent solutions are used for merely washing chalk and dirt from coated surfaces prior to repainting. Care must be taken when blasting wood and concrete/masonry not to damage it. We have found that Dr. Frenzel (Ref. 2) is correct in stating that pressures of 20,000 psi are necessary to achieve near white or white metal (SSPC SP-5) cleanliness. This pressure may be reduced somewhat, however, with injected abrasive. Corrosion inhibitor is always added to the water when waterblasting steel to prevent flash rusting. The effect of this inhibitor on coating performance has not been fully established.

Several Navy field activities have successfully used a proprietary combination of paste and petrolatum paste on steel surfaces that are merely manually or power wirebrushed to an SSPS SP-2 or SSPC SP-3 finish. Such surfaces as piping under piers do not require the pleasing appearance provided by conventional paints. The paste has also been successfully used to protect wire antenna cables. NCEL helped develop a system for remotely coating such cables (Ref. 3) with the paste.

NCEL has also investigated a number of primer paints to be applied over tightly adhering rust. Their performance has been less, frequently very much less, than that received over abrasively blasted steel.

Coatings with Low Amounts of Organic Solvent

Many locations, notable air pollution control districts in California, are requiring the use of coatings with low quantities of volatile organic compounds. This rules out the use of most federal and military specification paints.

Water-borne coatings provide a good-looking, breathing system for concrete/masonry surfaces. The mixing liquid of some of these coatings (e.g., TT-P-19) can be used to prepare fill coats to greatly reduce porosity. Water-borne cementitious coatings can be used to seal concrete/masonry surfaces from even wind-driven rains. Textured coatings (e.g., TT-C-555) are also available in latex compositions that will seal masonry walls from wind-driven rain. However, latex compositions of TT-C- 555 are reported (Ref. 4) to be less durable than other generic types of textured coatings.

Oil-based coatings have long been reported to be required for maximum protection of wood. A recent NCEL study of coatings on plywood (Ref. 5) has shown this not to be the case. This 4-year exposure study of 2-coat latex and alkyd systems showed that:

- (1) Latex/latex systems performed significantly better than latex/alkyd, alkyd/latex, or alkyd/alkyd systems.

- (2) Coating adhesion and wood penetration was as good for latex as for alkyd systems.
- (3) Either type of coating requires a minimum adhesion (12.0 kg/sq cm) for satisfactory performance.
- (4) Coating systems performed better over rough-sawn than smooth surfaces.

It may be necessary, however, to use an oil based paint or lacquer to seal knots or water-soluble extractables that occur in some woods.

NAVFAC is the custodian for specifications for a latex primer (MIL-P-28577) and a latex topcoat (MIL-P-28578) for steel. Although these specifications contain some compositional requirements, they are too broad to insure that products received under this specification will always perform well. NCEL has also received poor performance from many proprietary latex coatings for steel that were highly praised by their suppliers. The California Department of Transportation (Caltrans) has developed formulations for several latex coatings that have provided excellent protection to steel. The use of these or other paint recipes, however, differs with the Federal Acquisition Regulation philosophy of using performance rather than compositional specifications in order to achieve maximum competition. A very specific test method for establishing the performance of latex paints on steel must be developed before this system can be used effectively.

NCEL is also investigating the use of high-solids coatings that meet the solvent content requirements. They, of course, are generally more difficult to apply than thinner coatings containing more solvent. Thus, special equipment (e.g., heated equipment) may have to be used to apply some of them. NAVSEA is modifying some of the formulations for MIL-P-24441 to get them to meet present and anticipated solvent requirements.

Inhibitive Pigments for Primers for Steel

Red lead, zinc chromate, and other lead or chromate-containing pigments have provided excellent protection from corrosion to steel and other metals. Lead-containing paints are no longer permitted on housing and other structures to which children have access. Other concerns indicate that lead and chromium will no longer be permitted in any paint. They currently pose an expensive problem in their removal and disposal. Thus, Navy field activities are making greater use of the MIL-P-24441 epoxy-polyamide system in which the Formula 150 primer does not contain an inhibitive pigment. SSPC has specification alkyd paints without inhibitive pigments but states that these products sacrifice a significant amount of protection. Many private companies and government organizations are investigating the use of coating primers with inhibitive pigments that do not contain lead or chromium. NCEL is currently trying to find an acceptable lead and chromium-free primer for aluminum shelters.

Mildewcides for Oil-based and Latex Paints

Mildewcides are added to oil-based and latex paints to impart mildew-resistance to them. In addition to defacement of buildings, inhalation of

mildew spores and hyphae may cause bronchical problems (Ref. 6). Mercury-containing mildewcides historically have been very successful in stopping mildew growth. The use of mercurials in paint is now greatly restricted. Thus, we are required to use EPA-approved substitutes. This approval, however, just establishes environmental acceptability and says nothing about its effectiveness in controlling mildew. Thus, many Navy buildings with exterior paints containing EPA-approved mildewcides have had a heavy growth of mildew within three months. For this reason, NCEL has investigated this problem.

All available EPA-approved mildewcides were formulated into latex and oil-based paints for wood. Wood panels coated with these paints were exposed for one year in a rain forest at the U.S. Army Tropic Test Center site in Panama. Most of the paints had significant mildew growth within a month, and only one controlled mildew growth at an acceptable level for a year.

Mildew-contaminated surfaces are routinely cleaned with a solution of bleach and detergent before repainting. Some Navy activities first waterblast off the mildew and then kill the remaining organisms on the cleaned surface with bleach.

3 CONCLUSION

The Navy will conform to all environmental restrictions in its program of protective coating vital shore facilities. The task is made especially difficult in those areas where technology is lacking. Thus, we are conducting research and development and interacting with other technical organizations to obtain the necessary knowledge. We are dedicated to satisfactorily resolving this problem.

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SOLVENT RECLAMATION BY BATCH DISTILLATION

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ABSTRACT

This paper presents some basic concepts for applying batch distillation (BD) to reclaim solvents. The vapor pressure range of a solvent relative to that of its contaminants determines the feasibility of its separation via distillation. High boiling contaminants, e.g., waxes, oils, paint residues, etc., can be separated from solvents by BD. Solvents with high boiling points may be reclaimed by vacuum or steam distillation.

The basic elements of BD are solvent evaporation from contaminants, vapor-phase solvent enrichment, and condensation of distilled solvent. Some potential concerns are (a) thermal degradation, (b) flashing or ignition from leaks, and (c) low distillate purity. For typical DOD applications, BD is most feasible when the same unit is used to reclaim multiple solvents. Reclaimable solvents include halogenated vapor degreasers, mineral spirits, paint thinners like toluene and xylene, and precision cleaning fluids, e.g., alcohols and freons.

Reports indicate annual cost savings for 153 DOD bases amounted to \$10.3 million from solvent reclamation. Paint thinner savings amounted to \$1.9 million. Paint strippers and carbon removers are generally returned to manufacturer due to the difficulty of separating viscous multi-component wastes.

BD equipment design considerations are (a) types and quantities of solvents, (b) utilities available, and (c) solvent-use and batch cycle times. Operator attention is required only for loading and unloading charges and occasional monitoring. Simple physico-chemical test, e.g. absorbance, conductivity, acid acceptance, etc., can monitor the condition of in-use and reclaimed solvents.

Solvent reclamation by BD is a viable option for significantly reducing solvent replacement and disposal costs at many DOD installations.

Introduction

Significant quantities of waste solvents are generated regularly as a consequence of cleaning operations at Department of Defense (DOD) installations. The costs of new solvents and handling and disposal of these wastes are of increasing concern to DOD as hazardous waste regulations are promulgated.

Most solvents found in major waste streams can be reclaimed. These solvents classes include cold dipping and bath application solvents, e.g., Stoddard solvent, vapor degreasing chlorinated solvents, precision cleaners, e.g., Freon, and paint thinners.

Quality checks of the reclaimed materials indicate that the solvents are suitable for reuse in cleaning operations.

This paper presents the technical and economic feasibility of solvent reclamation via batch distillation.

Description of Methodology

Boiling of a pure liquid occurs when its vapor pressure equals the ambient pressure. In case of a mixture, the total mixture vapor pressure has to be equal to ambient pressure to enable boiling to occur. A pure component boils at a specific temperature, at a given pressure, known as the boiling point (B.P.). For example, at 1 atm. pressure, water boils at 212°F. A multi-component mixture boils within a temperature range depending on its composition.

A liquid's boiling point (B.P.) decreases with the applied pressure. Figure 1 shows the behavior of several halogenated solvents. For example, methylene chloride boils at 40°C at atmospheric pressure (760 mm Hg). However, if we reduce the ambient pressure to 400 mm. Hg. by applying vacuum,, the boiling point of methylene chloride is reduced to 25°C. This can be advantageous for high boiling solvents, e.g. Stoddard, if the solvent decomposes, flashes, or ignites above a certain temperature. For safety, we should distill at a lower temperature than the solvent's flash point. This may be done by either using vacuum or by adding an azeotropic component like water.

When water is added to an immiscible solvent two distinct liquid phases form. The added vapor pressure of water means that boiling will occur at a lower temperature than if only solvent was present. The compositions of the vapor and liquid phases are identical and is called an azeotrope. The significance of azeotropic distillation is that the solvent may be reclaimed at a lower temperature than its normal boiling point.

For each pound of material evaporated a certain amount of energy must be supplied. For example: At atmospheric pressure and 212°F, 970.3 BTU is required to evaporate one pound of water. This value changes with changes in temperature and pressure. The rate of evaporation depends on the rate at which this energy is supplied.

The three basic functions of batch distillation are: evaporation, enrichment, and collection. Figure 2 delineates the three functions on a typical commercial distillation unit.

In simple batch distillation, spent solvent is first charged to a vessel. The liquid charge is boiled and the vapors are condensed and collected as purified solvent. The contaminants are left behind in the vessel.

The particular unit shown in Figure 2 uses live steam injection to evaporate the solvent. Another method would be to use an electric heat source and add water to the charge. The liquid distillate is pumped to a separator to remove the water and the clean solvent is sent to storage.

Evaporation

The important factors of the evaporation stage of distillation are:

- A. The rate of evaporation is determined primarily by rate at which heat is supplied to the distillation vessel.
- B. At very high temperatures, degradation of the solvent could take place. Reducing the pressure within the system, lowers the boiling point. Also, equipment limitations may prevent the use of extremely high temperatures.
- C. Two ways of lowering the boiling point are:
 - 1) Operate under a vacuum. i.e. employ vacuum distillation.
 - 2) Use a mass transfer medium.

For example:

- a) Co-distillation with an insoluble lower boiling materials, such as water. In this case an azeotrope is formed and the azeotropic mixture will boil at a lower temperature than pure solvent.
- b) Pass a stripping vapor through the material. A stripping vapor such as steam is passed through the solvent. The steam heats the solvent raising its vapor pressure while mass transfer occurs from the solvent to the water vapor phase (see Figure 2).

Enrichment

As seen from the typical commercial distillation unit, the enrichment section plays a very small part in solvent reclamation. The enrichment section in the commercial distillation unit consists of a mist impinger.

Condensation and Collection

The condenser is the main piece of equipment within the collection section (see Figure 2).

In the condenser, the solvent vapors are cooled either by air, water, or refrigerant, and the solvent vapor is condensed to a liquid. It may be necessary to separate two collected liquid phases (e.g. water and solvent) which are immiscible in each other by gravity settling and decanting.

Problems in Batch Distillation Operations

There are several problems involved in batch distillation processes which are worth mentioning. Thermal degradation can be caused by poor heat transfer within the distillation chamber. The bottom of the chamber is usually hotter than the middle or top section. A very high bottom temperature could cause a chemical breakdown in the solvent which may hinder its cleaning performance. Another major problem often encountered in batch distillation is solvent purity. Impurities in the recovered solvent or a loss of inhibitors during the solvent recovery could hinder the overall effectiveness of the reclaimed solvent. Additional inhibitors or new solvent may have to be added to the recovered solvent in order to make the recovered solvent effective.

Solvent Characterization & Economics

The structure of major process use and solvent type is presented in Table 1. For typical DOD applications, batch distillation is most attractive when the same unit is used to reclaim multiple solvents as shown in Table 1.

A brief description of the major solvent applications is given below.

Vapor Degreasing

Vapor degreasing of metal parts are carried out using chlorinated solvents. Because of EPA regulations, 1,1,1 - trichloroethane is gradually replacing trichloroethylene and tetrachloroethylene at many DOD installations. Additionally, it is less toxic than most halogenated compound solvents.

Cleaning Baths

Mineral spirits, Stoddard solvent, or Varsol® (Exxon) are used in cold cleaning of parts and equipment. These compounds have low evaporation rates and high flash points, which are important factors from the viewpoint of safety.

Paint Thinners:

Paint thinner compounds include toluene, xylene, methyl ethyl ketone, and alcohols.

The three major applications of paint thinners are (a) to thin paint and coatings before application, (b) to clean surfaces prior to painting, and (c) to clean paint application equipment. The first two areas have wastes from which little or no solvent can be reclaimed. Besides, thinners used in these areas require tight formulation. The third area produces a waste stream which yields a significant amount of solvent(s) when reclaimed. The solvent formulation for this application is not very stringent. The thinners are generally mixtures of several solvents. It is not practical to use batch distillation to isolate each solvent unless several passes are made.

Paint Strippers and Carbon Removers

Paint strippers and carbon removers consist of mostly methylene chloride mixed with additives. The wastes generated have high disposal costs because of phenols and metal salts. Manufacturers of original stripper generally have a take-back policy because of their reprocessing capability. Material formulation is required to reuse the solvent as a stripper.

Precision Cleaners

The typical solvents are ketones and esters, which are used for cleaning surfaces prior to painting. Freons are used to clean electrical parts, and appliances.

Economics

A survey of literature on reclamation of solvent at DOD bases indicate that annual cost savings are already significant at installations where reclamation is being carried out, and the savings can be substantial if applied to all the DOD installations. A summary of the potential cost savings (annual) for military bases is shown in Table 2.

Reclamation of major solvents, as indicated by Table 2, can result in total annual savings of \$10.3 million. The paint stripper savings of \$1.2 million is mainly due to manufacturers take-back policy. Paint thinners can yield a savings of \$2.1 million.

Batch Distillation Unit Design

Consultation with various solvent reclaimers and reclamation equipment manufacturers yielded a set of five criteria to obtain the proper size unit for individual operation. The five criteria are:

1. Types of solvents to be reclaimed.
2. Type of contaminants in solvent.
3. Amount of solvent.
4. Utilities available.
5. Cycle times of solvents.

As most installations must recycle more than one solvent, information must be supplied for all solvents. The type of solvent and contaminants must be specified to allow for proper materials of construction and waste handling design.

The utilities available determine the heat source for the evaporation section. Most industrial batch distillation units are manufactured for steam heating but may be converted to natural gas or electricity.

Residence time of the solvents reclaimed is critical in proper sizing of batch units. The manager must consider the time required to reclaim each solvent used as well as the order of reclamation.

A summary of distillation equipment sizes is shown in Table 3. For large scale operations such as the 50-125 gal/hr range continuous operation is applied.

Batch distillation requires little operator attention. Most attention is required at the beginning and end of each cycle and occasional monitoring during the cycle. Two methods employed to determine the end of the cycle are temperature set point and cycle time. For temperature set point system once a certain temperature is reached the operation is stopped. For the cycle time method, a set amount of time is allowed to pass and the distillation is terminated.

The typical distillation equipment costs are shown in Table 4.

The sizes are based on amount of product collected per hour. The Vara international unit is custom fabricated and includes all necessary controls. The DCI unit includes the still and separation equipment. When choosing a system one must consider the parameters that will allow maximum flexibility (e.g. Robins Air Force Base has a vacuum system to handle Stoddard Solvents even though Freon, another solvent reclaimed, needs no vacuum.)

Reclamation Scheduling

In order to optimize the reclamation of multiple solvents in a single unit, the order of reclamation must be considered.

If a large inventory is not available, then the solvent order may have to be staggered, so that all the solvents are reclaimed in accordance to their rate of generation. In this case, proper coordination between the waste generation schedule, reclamation schedule and the usage schedule is essential. Optimization techniques, e.g. linear programming may be useful in this regard.

Physico-Chemical Tests of Solvent Performance

Several physical and chemical tests are available to determine when a solvent should be recycled and to monitor reclaimed solvent quality. These tests require simple equipment and can be quickly performed.

Electrical conductivity can be measured by dipping a conductivity probe in the solvent, and observing the reading on a conductivity meter.

Visible absorption spectrophotometry measures the absorbance of liquid at a specified wavelength and is useful in characterizing petroleum products.

Specific gravity is a comparison of the density of a solvent to the density of water, and is often an indicator of the amount of impurities in a solvent.

Kauri-Butanol Value gives an index for ranking solvents. The basis is the fact that kauri gum is very soluble in butanol but the solubility decreases as butanol is diluted by a solvent that will not dissolve the gum. The gum will tolerate a large quantity of good solvent but only a lesser amount of used solvent.

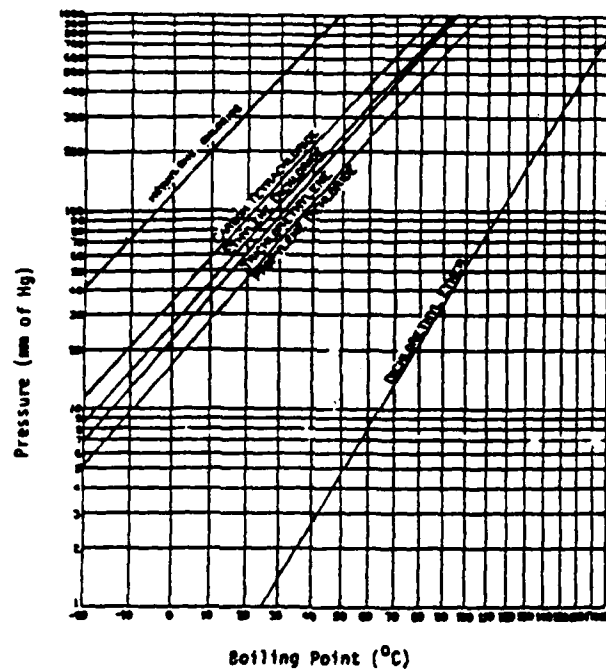
Viscosity represents intermolecular interaction. As a solvent becomes contaminated the viscosity usually increases.

For Stoddard solvent, the visible absorbance, viscosity, electrical conductivity and specific gravity appear to give best indication of when to remove solvent from a vat and also can be used to perform quality control checks of recycled solvent. For trichloroethylene and other halogenated solvents, absorbance, electrical conductivity, and acid acceptance value give the best measure of the degree of contamination of the solvent and quality of the recycled solvent.

Conclusions

- . The three basic functions of batch distillation are:
 - a. evaporation
 - b. enrichment
 - c. collection
- . Many DOD installations are successfully recycling spent solvent and thereby reducing new solvent and disposal cost.
- . Various simple analytical methods are available to:
 - determine the feasibility of reclamation
 - determine when a solvent should be recycled
 - monitor the quality of the reclaimed solvent
- . Batch distillation is most economical when a single unit is used to reclaim multiple solvents. The usage schedule (gallons per week, month, etc.) and the reclamation schedule should be coordinated to optimize the process.
- . For accurate sizing of a batch distillation unit, the following factors must be considered.
 - a. Number and types of solvent to be reclaimed
 - b. Quantity of each solvent
 - c. The order of solvent reclamation that minimizes contamination and cleanup.
- . On-site reclamation is not always possible for some solvents e.g., paint strippers. These wastes are often returned to the manufacturer for reuse or disposal.

Figure 1



Boiling Point Variation with Pressure for Various Chlorinated Solvents.

Source: Mellan, I., "Industrial Solvents", 2nd Ed. Reinhold Pub., New York, New York, 1950

Figure 2

TYPICAL COMMERCIAL BATCH DISTILLATION UNIT: Dyme I System

Flow Process
Standard
Live Steam
Injection Model
DCI Corp.

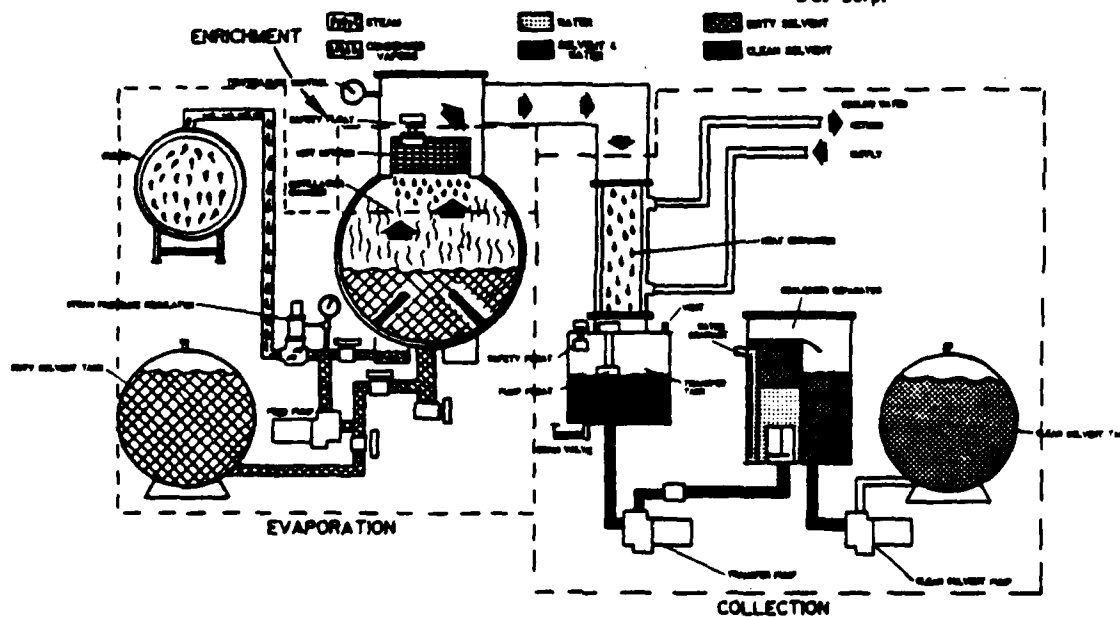


Table 1

SOLVENT APPLICATIONS ON DOD BASES *

Process Use Categories	Classes and Types
Vapor Degreasing	<u>Chlorinated</u> 1,1,1-Trichloroethane Tetrachloroethylene Trichloroethylene
Cleaning Baths	<u>Mineral Spirits</u> Stoddard Solvents Varsol PD-680
Paint Stripping and Carbon Removing	<u>Chlorinated</u> Methylene chloride with Additives ¹ (phenol, ethanol, petronate HL, water, toluene paraffin, sodium chromate, methyl cellulose)
Paint Thinners	<u>Oxygenated</u> Methyl Ethyl Ketone Toluene Xylene
Metal Preparation and Precision Cleaning	Alcohols and Freon

* See. R.W. and K.E. Kawasaka, "Evaluation of Disposal Concepts for Used Solvents at DOD Bases", Contract No. F04701-82-(0083). The Aerospace Corporation, TOR-0083 (3786)-01, Feb. 1983.

1-additives list obtained from Robins AFB, GA.

Table 2

ANNUAL COST SAVINGS FOR LARGE & SMALL BASES

Solvent	Disposal Option	Cost Avoidance for New Material per base	Cost Avoidance for Disposal per base	Savings per base	Total Savings for all bases (million \$)
<u>Large Bases (29)</u>					
TCE	Recycle on Base	\$74,250	\$36,000	\$110,250	\$3.2
PD-680	Recycle on Base	39,600	9,900	49,500	1.4
Paint stripper	Manufacturer-take-back U		40,425	40,425	1.2
Paint Thinner	Recycle-on-base	41,940	7,555	49,995	1.4
Freon	Recycle-on-base	28,512	3,037	31,549	0.5
Total For Large Bases		\$184,302	\$96,957	\$281,219	\$7.7
<u>Small Bases (124)</u>					
PD-680	Recycle-on-base	\$11,880	\$3000	\$14,880	\$1.9
Paint Thinners	Recycle-on-base	5,130	1000	6,130	.7
Total for small Bases		\$17,010	\$4000	\$21,010	\$2.6

Ref: See. R. W. and K. E. Kawasaka, "Evaluation of Disposal Concepts for Used Solvents at DOD Bases," Contract No. F04701-82-(0083). The Aerospace Corporation, TOR-0083(3786)-01, Feb. 1983.

Table 3

TYPICAL COMMERCIAL SOLVENT DISTILLATION EQUIPMENT

Size	<u>Small</u>	<u>Medium</u>	<u>Large</u>
Flow rate	15 gal/hr	15 to 50 gal/hr	50-125 gal/hr
Type of Operation	Batch	Batch or continuous	continuous
Solvents used	Paint thinners and chlorinated solvents	all solvents	
Attention Required	Automated Shutdown at end of batch	Automated, Requires operator attention at end of batch	Automated with occasional operator checks
Cost	\$3,000-\$5,000	\$30,000-\$60,000	\$60,000-\$100,000

* Bee, R.W. and K.E. Kawaka, "Evaluation of Disposal Concepts for Used Solvents at DOD Bases", Contract No. F04701-82-C-0083, The Aerospace Corporation, TOR-0083 (3786)-01, Feb. 1983.

Table 4

TYPICAL DISTILLATION EQUIPMENT COSTS

<u>Manufacturer</u>	<u>Size(gal/hr)</u>	<u>Cost(\$)</u>	<u>Additional Costs for Vacuum System (\$)</u>
Distl Inc.	*10-20 *80-140	50,000 100,000	5,000. 5,000.
DCI	100 500 1000	42,600 63,100 77,800	7,600. 11,200. 15,700.
Finish Eng.	7 30	14,700 40,000	6,400. 16,000.
Gardner	50 100 200 500	50,000 70,000 103,000 133,500	Included Included Included
VARA Int'l	+20	125,000	Included

* Stirred Tanks
 * Custom fabrication including controls.
 All are constructed of 304 ss material

RESEARCH AND DEVELOPMENT

SESSION IV DISCUSSION

(Daly): I am thinking about the place I'm working and the solvents that are being disposed of. I am wondering if we really need to keep the bath so clean that we have to go through installations and have people concerned about some sort of filtration or absorption. Is it clean enough? Because here you're coming back to pure new stuff, and it seems to be that it would be more expensive. I wonder if we couldn't just strain out all the big junk?

(Donahue): It depends on what you use your solvent for. If you are using it in an open bath and you're cleaning greasy vehicular parts, that is fine. Then all you have to do is take the particulate matter off and use it again. You have to keep adding to it. However, at Anniston or Corpus Christi where they have some critical cleaning jobs to do...

(Daly): That is what I don't understand. I would like to make a comparison. What do they clean?

(Donahue): At Corpus Christi, where they rebuild helicopters, they clean all the bearings, test them, and check to see if they can use them again. You have to have a pretty clean solvent.

(Daly): You don't want residual?

(Donahue): That's correct.

(Mikucki): In conjunction with Bernie's work, when you saw that slide that talked about tests that check the quality of cleaning solvents, we're more interested in whether or not a simple test could be used to determine when a solvent is spent. For two reasons: 1) for the change out in particular application, 2) for a possibility of being used as the solvent at a quality that is suitable for successive degradation uses of solvents. Thus going a long way to minimizing.

You're correct in your perception that in many instances it's the person's perception of dirty that results in a specific cycle time suggestion of solvent as spent. And in some instances, we have been looking at whether or not we can do something to take advantage, or to color, that perception of dirty. Some of the samples of materials that we have acquired for use in our research as "spent solvent" have things that were turned in to DRMS for disposal. When we did a laboratory distillation for the 97% solvent, and 3% by volume of contaminants. The solvating power doesn't disappear, per se. There is nothing that's physically irreversibly tied up. It does get dirty, and there may be different degrees by which you can take out that dirtiness.

(Donahue): We had a still here in the past couple of years that we have tried. Distillation is a closed process. They're sealed and they vent to the outside if they are hooked up properly, so you can use them almost anywhere.

The point I wanted to make was that we have a paint laboratory here that generates some waste solvent. Al Beitelman provided me with a nice batch of waste solvent which I put in this cooker and got him a product. The problem was I did not know what temperature to shut it off. I cooked it a little too long and this horrible mess was

left at the bottom of the still. Al wasn't happy with the product. It had a lot of carryover. I'm sure I cooked it too high.

(Novak): What are the energy sources for heating the solvent? Is anyone using microwaves?

(Mikucki): Not to the best of my knowledge. That might be one way to get at it without burning or with more uniformity. Another thing that can tolerate the water content is direct stream injection, the easiest and most uniform heat transfer. Short of that the pot stills operate on a basis of electrically heating the circulating oil. There are other sources of heat, yes, but I am not sure if they can apply.

CONCLUDING DISCUSSION ON RESEARCH AND DEVELOPMENT NEEDS

(C. Meyer): We all owe you a debt of gratitude for the fine job you did in coordinating this workshop. I was pleased to see the amount of interaction we've had here and the good discussions from each one of the speakers that has made this a real valuable workshop. I just want to touch on a couple of things: After I do that I would like Ed Novak to come back up and try not to let this go to waste in terms of CERL. We need to try to pick out some areas that we might use for future cooperative research development in the Army, Air Force and Navy, so Ed is going to come up and do some brainstorming with you all, so that we won't lose a lot of the information that we have gained in the last day and a half.

I am at the Office of the Chief of Engineers Research and Development Directorate, and we have three labs that work in the Environmental Quality arena. One is CERL and another is WES, a large facility that has done a lot of work for EPA and other DOD and government agencies, and the third is CRREL that specializes in cold regions applications and particularly, again, the hazardous waste arena. We have three labs that work that. In addition, we also serve as the DA Directorate Monitor for USATHAMA, where Dave Bernard works, and with the Surgeon General's Lab, USAMBRDL in Maryland. They primarily work in the health criteria arena developing the health criteria documentation and work with EPA in terms of developing health advisories. When we get into those "superfund" type applications in the service we can determine how far we have to clean up an installation or "how clean is clean." USAMBRDL then develops the health criteria documentation for the Corps.

We also have had for 5 years a cooperative MOU with EPA for research and development that is being updated right now. In fact, it is back over at EPA Headquarters. It is under the MOU that we conduct workshops as we do joint field demonstrations at Army installations. We are proud of the fact that we do have the MOU and do maintain it to keep it active and do at least two or three joint projects with EPA each year. Of course, this would be one of the joint projects that we do with the EPA. We are also working with EPA on a program with the Air Force and Navy as EPA gets its reauthorization and surplus SITE (Superfund Innovative Technology). EPA will be looking for possible candidates at our facilities. Of course, the DOD has the main facilities, the Depots and the Army Ammunition plants and the Air Force's depots and whatever we might identify as potential sites that the EPA can test. Technologies appear to be useful from commercial interest for cleaning up sites, CERCLA superfund type sites. That's another cooperative effort that we will have with EPA in the future.

I'm really somewhat pleased with the Army Environmental Program as we start to develop the 87 budget and as it goes through Congress. I think the Air Force and the Navy are starting to get their cuts, and ours has gone anywhere from 10 to 20 percent of the different projects that the Corps has. Of a total of about 80 million dollars of R&D money, there are about 11 million in the Environmental Quality arena. None of those projects were even touched through the Congress. Whether that is due to the quality of the program, or whether it's just oversight, I don't know. We feel that they can see that just about \$300,000 of that 11 to 12 million dollars was touched as we go into the 87 budget. We are also trying to point out the interest in the Army and the other services for hazardous waste management. We will also be inviting Chiefs of Staff of the Army on the 15th of October.

Some of the areas we will touch upon during the briefing are asbestos, waste minimization, hazardous waste disposal, low-level radiation, PCBs, leaking underground storage tanks, research and development, and resources. The last one, resources, is important because the Army is starting to realize that they are going to have to pour dollars in this area of hazardous waste management. We haven't seen it so far, but I think we will start seeing it within the next year or so. I think it comes to the level of awareness and the level of importance that we really have to start paying attention to hazardous waste management obviously because of the regulations and also because of potential dollars saved. The Army realized it can save a significant amount of total dollars by putting dollars up front, especially for hazardous waste management. That is all I really had to say in terms of my remarks about the importance of workshops like this. It is tremendously important in terms of joint services benefit and also the work of the EPA. At this point, Ed, I would like to ask you to do a little brainstorming so that we can see, especially people out in the field, exactly what we have done in the area of research and development where in the next several years we'll have a good R&D program.

DISCUSSION

TOPICS OF DISCUSSION

- 1) PAINTS AND COATINGS FORMULATION AND MANUFACTURING
- 2) REGULATORY RESTRICTIONS
- 3) WASTE DISPOSAL
- 4) WASTE REDUCTION

(Novak): We will review the major topics covered. We want your good ideas. We are looking for technology gaps. Where do you feel we should spend research dollars? Where has research not gone far enough? What questions do you have that research and development can solve? Then, if there is time, we will vote on priorities.

(Mikucki): In view of what the paint waste problems are, how much R&D are you putting into this DA or DOD EPA interaction? I understood THAMA had funded the work on dry blast media. Is EPA doing anything that they are funding? Is there anything to report on hazardous waste problems?

(Darvin): I can only respond from the air side. Over the last 5 to 6 years we have put in 2 to 3 million dollars of research in the area of controlling the VOC emissions from paint operations. The work that we have primarily done includes looking at ways of modifying manufacturing techniques. We either enhance the resulting airstream or we can easily eliminate or destroy the airstream. We have been looking at process modifications along topics that were mentioned earlier with transfer efficiency. We just completed a major project to look at ways of improving transfer efficiency or those parameters that actually effect transfer efficiency, thereby we can modify those in some way so we can increase the painting efficiency of available painting equipment. We have been putting money into it.

(Mikucki): I guess I wasn't doubting that so much as wondering from the air side of the VOC that reduction is important. What about from the hazardous waste side, which is where EPA has the bulk of its R&D money. Is there anything going on from that standpoint? Are there "more alligators, and are these things only small?"

(Wilmoth): I can answer a little of that. They are looking for the bigger efforts more than for the R&D effort. The work right now has been to take a look at the techniques that do exist and are in use rather than R&D. The hazardous waste area to a degree is looking at existing techniques as opposed to looking at any more exotic, innovative techniques that are in use.

(Novak): Adaptation of existing technology.

(Wilmoth): Exactly. Once the actual plan limits are determined where the actual existing technologies are not going to work, then from that point on the agency will take a look at the new techniques.

(Novak): In paint formulation and manufacturing, what pressing problems still need to be solved with regulations?

(Kish): We're not so much in conflict with regulations but find ourselves technology driven, or government forcing technology. We don't object to that though. One comment that I would like to make is that the paint industry is hopefully a profit-oriented organization and consequently we can't be all things to all people. The technology may be available to do something, but in terms of priorities, it might not be in the direction we would choose to go. For example, if we're not active in a particular field or we're not supplying paint to a specification or are supplying a minimal amount and there is a requirement for a VOC, I really can't direct research efforts into complying with that when I have other things that have to be addressed. In terms of paint formulation and manufacturing, there may be a need to develop compliant coatings within the government where industry is not currently active.

(Beitelman): Are you asking for formulation type specifications? If the government can ask for formulation type specifications, it would eliminate any R&D that the private industry would have to do to meet that standard.

(Kish): It would be a logical approach. I'm not saying or advocating it, but I think it's in the area where if paint companies were not active in the field, then something like that would be very helpful.

(?): How are we going to leave it then--the government R&D's formulating compliant coatings?

(Kish): My suggestion would be that industry is addressing many of the specifications as in my own company. For the polyurethane specification, the CARC coating, we have high solids compliance versions of those materials. Other companies do as well. In the area of the old alkyds, my company is not developing compliant coatings simply because the market is going downhill and we are inspecting other areas. If there is a need to comply and have other compliant materials, it may be necessary for the government to develop their own specifications and then find someone to manufacture them.

(Darvin): I would just like to say as far as EPA is concerned in paint formulation research, we have stayed away from that because there are an infinite number of requirements which would require different specifications and formulations for each one of the requirements. We have especially stayed away from that type of research. Although regulations drive, we have left the actual formulation to industry.

(Novak): I'd like to express, if we haven't already, improving paint quality. We're having to come up with new solvents that will make a good or better paint than we have out there right now because of what we have to do to meet these regulations.

(Beitelman): There have been a certain amount of performance specifications that have come out. The contract writer comes along and says, "Hey, that looks like the kind of paint I need for this job." He puts that into a contract and lo and behold the successful bidder can't find anyone to make it. Presumably, some company made one batch one time. The paint industry, in general, would have to do major research in order to meet that specification, and they aren't going to do it--not for a couple hundred gallons of paint. So we're stuck with perhaps the one company that made the one batch.

(?): We recognize that. There is an effort underway at the present time by Ft. Belvoir for the removal of all A10 paint items, the specifications and whether they comply with the VOC regulations. That report is due from the Army tomorrow. From their input, I think you can answer your research efforts in the paint formulation area. There are about 560 specifications that are being reviewed. The presumption is there will be about 300 less after the review. The rest will probably be cancelled. They will need reformulation to comply with the VOC regulations. I would say that this is possibly your major effort in the paint formulation area, review that study, and then decide which coatings to reformulate. We on the Civil Works or Public Works area need this input so we can specify our paint system. There is really a driving need for R&D efforts.

(Svec): The way research money could be better spent in many cases is to research ways for us to use the coating we want to use as opposed to trying to reformulate coatings that are not working.

(Novak): So you're talking about the application process?

(Svec): I'm talking about R&D in the sludge removal system in the stack area so we can use the coating we need to use to do the job that we need to do without worrying about VOCs and without worrying about so much waste generation. There are definitely sludge removal systems on the market for paint strippers. There are ways that need to be tested and adapted. I know of no stripper that will remove epoxy without methylene chloride. We need ways to make methylene chloride safe to use.

(Darvin): There are two ways to control pollution. You can either not generate it or not use the pollutant in the first place or you can control it. It comes down to the process. I think you are going to have to do some process development-type of research to allow you to continue to use what you are using. There are going to be some instances that you're not going to be able to change, you are going to have to continue to use it. EPA and its regulations, in most instances, do not necessarily say that you cannot use a certain compound. They say that you will control the discharge of that compound to a certain level. How do you do that? You either get rid of it or you change your process or you control that process such that it does not create a pollution problem.

(Novak): So you see nothing wrong with that suggestion. Neither do I as long as we're still abiding within the letter of the law.

(Darvin): That's correct.

(?): I think we're also talking about how many times you apply coatings of this nature.

(Svec): I'm talking about facility control. I've got trichlorethylene vats that I can't get sludge out of the bottom. Sludge removal systems so you can cut down on your pollution level.

(Wilmoth): We're working with Dave Renard on what I believe is the largest type of R&D need, in terms of where I'm looking at things, and all of these things go together. If you look at each of the individual items we've written out there, what you're looking at is kind of a multimedia and control technology map where all these elements are indeed elements of a larger overall development. If you tend to look on one of them, it's got an impact that's going to carry over into each of the others and there is no one there that is going to act on its own. They are all interrelated. The type of work that we're doing today in looking at multimedia control is optimizing the overall interrelationship. To come off with an end result, which is better than trying to look at each of the individuals.

(Novak): What we are looking at is management. We will go through the entire life cycle of everything; the whole process.

(Bernard): Technology defines what the needs are and the guidebook as to a selection of product so you can do it with the understanding of what we're doing to other media, the effect on the other media, and trying to minimize that impact.

(Novak): It would be more generic because there are so many applications, paints, conditions, and situations.

(Bernard): Yes, this is sort of a framework for any specific application.

(Novak): Sort of a "guidebook" as you put it. Yes, that's a useful product.

(Mikucki): It certainly would be useful to those of us who are aiming our research at facilities engineering. The regulations on the board there have to do with controlling painting in industrial facilities. Perhaps one of our EPA representatives could answer a question. Do you envision some future time in which architectural coating type of paints and coatings will be subject to any air regulations? Our Facility Engineering support activities are dealing with the hazardous waste aspect alone. There is no sense in me lobbying to make our very scarce base support-type environmental R&D dollars go to do VOC emission control for architectural paints for facility engineering if that is not going to come about. We are supposed to be able to anticipate the problem and have a solution about the time the problem rears its head, if the R&D idealized cycle is working, but there is no sense in "beating a dead horse." If it's not annoying you, then we concentrate on the residues of the paints and paint washings and things of that nature that result in hazardous wastes.

(Svec): I guarantee that we will never be able to 100% get VOC compliant coating on military equipment productively and have it function the way it is supposed to function. I'm talking about conductivity and other problems. For the military sales, if they don't want CARC paint on their vehicles, but want something else, we give them what they want.

(Rittenhouse): As far as architectural coatings go, I really don't think we have to worry about that.

(Mikucki): At an Army industrial facility with a number of buildings, could they bubble by a cut in the overall VOC emissions from the bubble by using latex paint on the outside of buildings, for example.

(Spyropoulos): As we suggested, the bubble is permitted if the overall pollutant is 10% less.

(Mikuck): But you have to do extensive modeling or have a year's worth of data to support your proposal.

(Spyropoulos): No. You have to send information to indicate where the emissions occurred with the bubble, but don't need any extensive amounts of time to do that.

(?): I attended a briefing by the National Paints and Coatings Association Legal Counsel last week and the information on architectural paints and regulations that they were espousing was that there had never been a regulation except in California for architectural. Until recently there had been no EPA management emphasis on architectural. Because there are so many nonattainment areas now occurring in the country, we can expect architectural to be controlled. I would say it is just over the horizon before architectural will be controlled.

(Rittenhouse): All these various solvents that you're talking about are going to be more restricted. They have been on our restricted list for a long time. It's just a matter of the EPA tightening up its regulation even further. You are going to have problems dealing with use of solvents in any case. This is just something, as we are finding out, that the landfills are leaking solvents very easily. Something has to be done!

(Novak): If we are not getting into the landfills, if we are using robots to apply the thing, and it's all self-contained, we've got the problem solved. It's not hazardous waste as long as it is being recycled or used.

(Rittenhouse): The recycling exemptions that used to exist for a lot of things, including solvents, got cut down rather considerably in the recent amendments to RCRA. The landfill situation is the worst part that is starting to come to our attention. Other things are starting to come in as well. It is going to get tighter no matter what.

(Novak): Words of warning?

(Rittenhouse): Yes, words of warning.

(Christman): It's not something that's architectural coatings in California that you call the barrier, and along the South coast, you'll see that there are a whole list of exemptions under Rule 441 covering the coating and miscellaneous manufacturing of metal parts. Architectural coatings happen to be one of the exceptions right now because they are working on regulations to cover architectural coatings and such. It's not just architectural coatings. There are 10 or 15 other items, so when you get down to nonattainment areas that have already been dealt with, a majority of the things that we can deal with are nonattainment areas. Now we are getting down to the smaller areas. Film coating, for example, is one that the Bay Area just proposed. Can coating, aerospace coatings, vehicle coating, plastic polymer coatings, a whole list of proposed development regulations that will be coming down the line in the next couple of years besides architectural coatings.

(Rittenhouse): The State of California is taking a much stronger stand on this and putting on some very tight regulations; more so than the Federal EPA. If you want to have some sort of long-range idea of where the EPA will be sent by Congress, I would say take a look at California.

(Christman): Something that bothers me when attending some of these seminars is there is a lot of discussion concerning paint, paint, paint. I keep thinking about all other spectrums of coatings we do besides paint! Paint certainly generates a lot of things right now, but for electronics we are spending more money on electronic warfare development items than anything else. Do we paint printed circuit boards? NO. We apply some type of coating to those and if we get into chip manufacturing what will we have to do to repair these high-tech kinds of items. Silicon Valley has got arsenate and arsonite and all kinds of problems that they are contaminating ground water with! What are we doing about it NOW? We're spending all this money to get into the electronic business. Are we looking far enough in advance to know that when it gets down to the individual depot installations who have to either repair or manufacture something to repair it; are they going to have the environmental tools they need to do it? The data that show up on the depots are usually too late. That's particularly critical to us at the Army Depot right now because we are looking into directed energy areas and the high-tech areas. You are talking about some very exotic kinds of chemicals to get into those things.

(Novak): You are saying that we need to be aware of the whole coatings area more intimately than just picking on painting.

(Christman): Absolutely! Use plating, for example. We are doing cadmium plating. I have a chemist that has been telling me for the last 3 years that there is no reason for doing cadmium plating, we could use zinc plating instead of cadmium plating. I don't know if anyone has looked at substitution. Is the military specification really required if the state-of-the-art now is at the point that we don't need to specify that kind of coating?

(Novak): You are making some good and powerful suggestions for some things that we should look into with some of the same group and some other people to really broaden our thinking in the area of coatings and protective coatings in one form or another rather than focusing on paint. This could be something that I would suggest to Dr. Meyer that we might be looking at down the line in Fort Worth just as thickly as anyone else, particularly in the areas of the various types of coatings you have been mentioning.

(?): I'll echo what my counterpart said from the depot in terms of equipment. One last thing, we can formulate all the great paint formulations we want to in the world on the market. If we don't have systems available to apply the coatings, they are absolutely worthless. Now we are saying high-solids coatings, and we don't have the equipment to apply high-solids.

(?): Then who is going to develop them?

(?): Exactly! Are we going to spend lots of money; can we use what we have?

(?): Okay, in any of these other categories, is there anything that anyone else wishes to add? We are now getting close to a conclusion. Is there anything anyone else would like to say?

(?) One area that bothered me to some extent is the delisting of waste. Until 1976 we did not have RCRA and now we have the 1984 amendments and the EP toxicity limits that were written and proposed being 10 times the drinking water standards; then they came out to be 100 times the drinking water standards. Suppose you delist your waste and the toxicity limits do not exceed your present guidelines, once you get all that material buried on your installation the rule changes! We have already on our installation spent 10 million dollars excavating 62,000 tons of contaminated earth hauling off a

couple of million gallons of liquid materials in a lagoon we have and got over a hundred monitoring wells, planning four ground water treatment projects. It's hard to keep moving, but as long as we can save money right now and delisting, perhaps burying it on our landfills, is that a good idea?

(Novak): That is a very soul-searching question. That is what we are trying to prevent. The delisting idea is an easy out, but who is going to pay for it? Your children, my children, somebody somewhere along the line.

CONCLUSIONS AND RECOMMENDATIONS

The consensus reached in group discussion at the conclusion of the workshop was that the following topics (related to environmental concerns in the life-cycle of paints and coatings) need research and development:

- Transfer efficiency of coatings to surfaces to be coated.
- Adaptation of existing technology to improve compliance with environmental regulations for painting and coating operations.
- Multimedia control technology.
- R&D on sludge removal systems and stack scrubbers for existing coatings.
- Control of volatile organic compound (VOC) emissions from architectural coatings in the future.
- Coatings other than paints.
- Government specifications for coatings in compliance with environmental regulations.
- Review of current military specifications for coatings. Are they required?
- Consideration of delisting of wastes. Is it wise in view of potential future liabilities?
- Additional methods of paint stripping.
- R&D to develop non-toxic lead- and chromate-free "rust inhibitor" type pigments which at least nearly match performance of the replaced pigments for maintenance painting of steel structures.
- Development of new devices or systems to contain and collect blast media and debris when blastcleaning steel structures, particularly for containing lead paint blast debris from cleaning the high arches of large bridges.
- Investigation of disposal of blast media and debris by permanent encapsulation in Portland or asphalt cement. It was suggested that the concrete could be used for construction of air base runways and that the asphalt could be used for roads on U. S. Army installations.

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